

**Experiment on impact
of constrained orbit parameters
on station coordinates**

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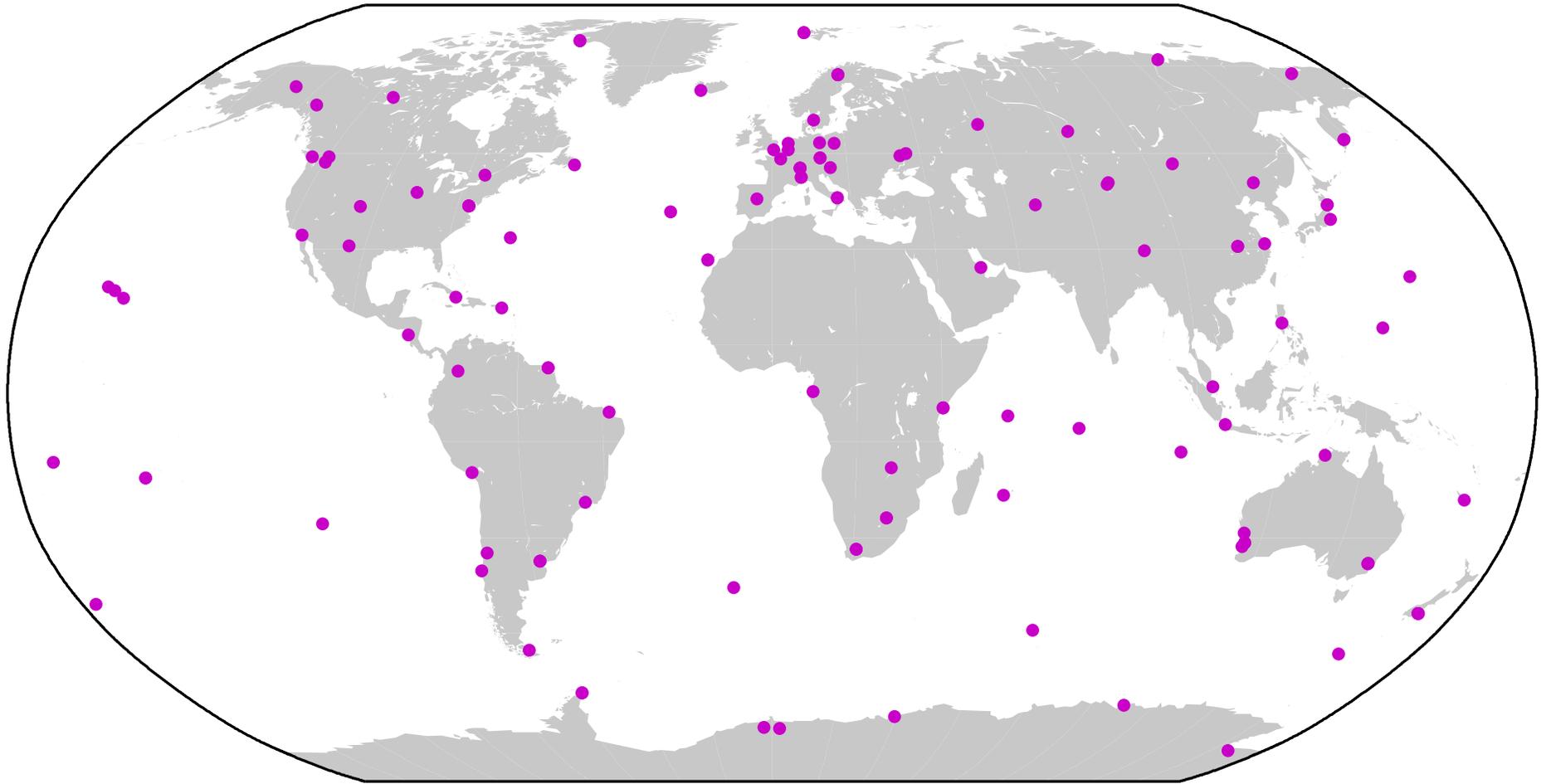
European Space Operations Centre;
Robert Bosch Strasse 5; DE-64293 Darmstadt; Germany

Z. Altamimi

Institut Geographique National;
6-8 Avenue Blaise Pascal; FR-77455 Champs-sur-Marne; France

IGS AC Workshop
Miami, 02.-06. June 2008

Network used for this experiment



126 stations; processed for GPS weeks 1471 to 1474

Solution description: AIUB (1/2)

- Software package: Bernese GPS Software
- Parameters solved for:
 - Station coordinates
 - Troposphere parameters (02:00 hourly, piece-wise linear, pre-eliminated)
 - Earth rotation parameters (12:00 hours resolution, piece-wise linear)
 - Geocenter fixed
 - Orbit parameters (in independent three-day-arcs)
 - * Initial conditions
 - * Radiation pressure coefficients (RPR): direct, Y-, and X-direction
(an offset and one pair of once-per-revolution for each component)
 - * empirical velocity changes every 12 hours
- Weekly solutions generated from seven 3-day solutions

Solution description: AIUB (2/2)

- Constraining of parameters:

Parameter type	Solutions	
	default	free orbit
Station coordinates	Minimum constraint solution with NNR+NNT ^a realized via IGS core sites	
Earth Rotation Parameters	no constraints apart from the first UT-value	
Initial orbit conditions	no constraints	
RPR	$\sigma(Dsin, Dcos) = 1^{-12}$	no constraints
	$\sigma(Ysin, Ycos) = 1^{-12}$	no constraints
velocity changes	$\sigma(radial) = 1^{-6}$	no constraints
	$\sigma(along) = 1^{-5}$	no constraints
	$\sigma(cross) = 1^{-8}$	no constraints

^a Alternatively a second pair of solutions without NNT condition has been generated

Solution description: ESOC (1/2)

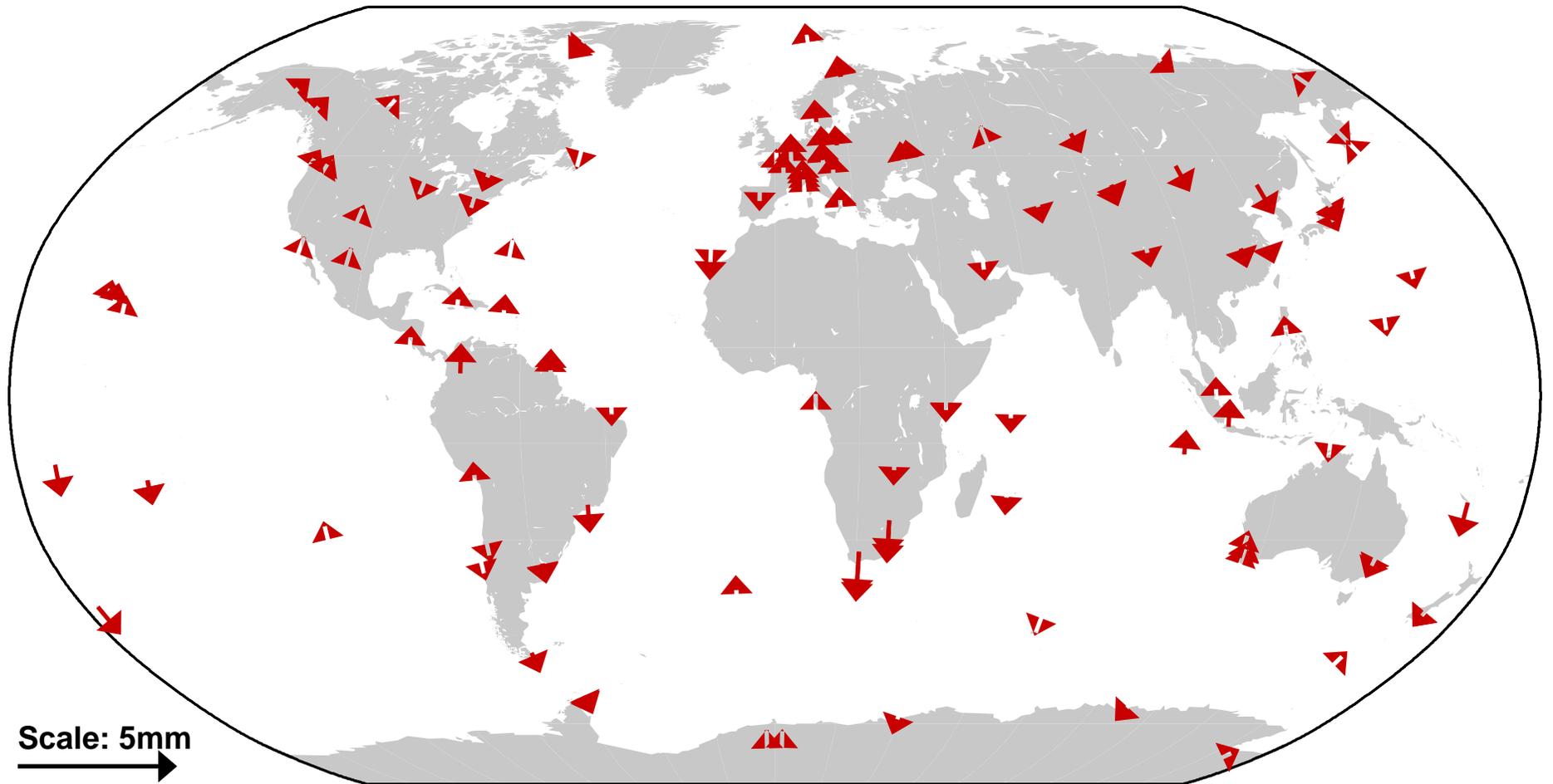
- Software package: NAPEOS Software
- Parameters solved for:
 - Station coordinates
 - Troposphere parameters (2 hourly, piece-wise linear, pre-eliminated)
 - Earth rotation parameters (24:00 hours resolution, offset and rate)
 - Geocenter fixed
 - Orbit parameters (in independent 24-hour-arcs)
 - * Initial conditions
 - * Radiation pressure coefficients (RPR): direct, Y-, and X-direction
(an offset and one pair of once-per-revolution for each component)
 - * Once per Revolution parameters (CPR): Radial, Along-, and Cross-track
(an offset and one pair of once-per-revolution for each component)
- Weekly solutions generated from seven 24-hour solutions

Solution description: ESOC (2/2)

- Constraining of parameters:

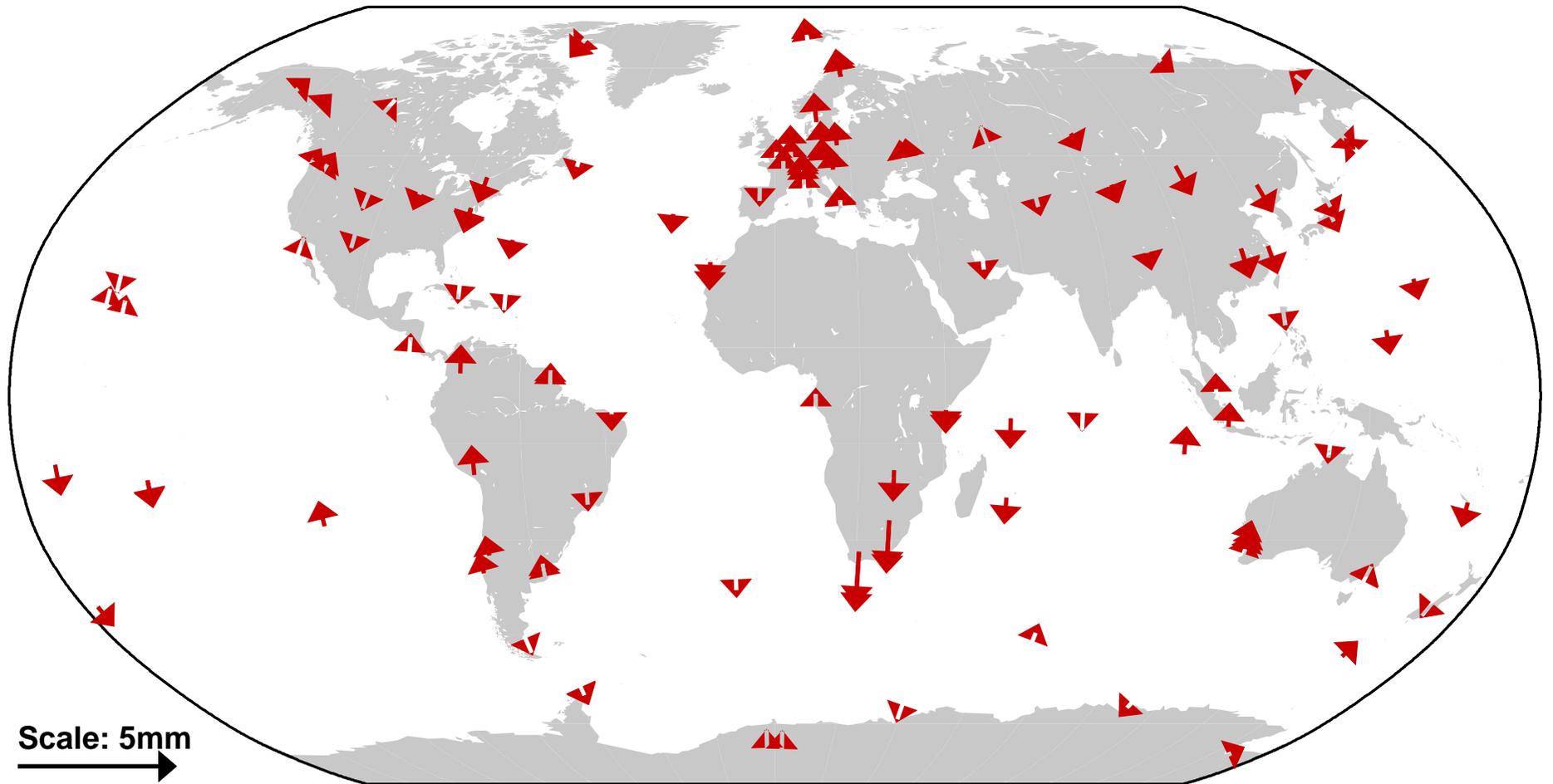
Parameter type	Solutions	
	default	free orbit
Station coordinates	Constraint solution using 100 mm realized over all sites	
Earth Rotation Parameters	Tight constraint on the UT parameters $1^{-13}ms$	
Initial orbit conditions	no constraints	
RPR	$\sigma(Dsin, Dcos)$: fixed	no constraints
	$\sigma(Ysin, Ycos)$: fixed	no constraints
CPR	$\sigma(radial)$: fixed	no constraints
	$\sigma(along) = 1^{-13} km/s$	no constraints
	$\sigma(cross)$: fixed	no constraints

Coordinate differences between “free orbit” and “default” solutions



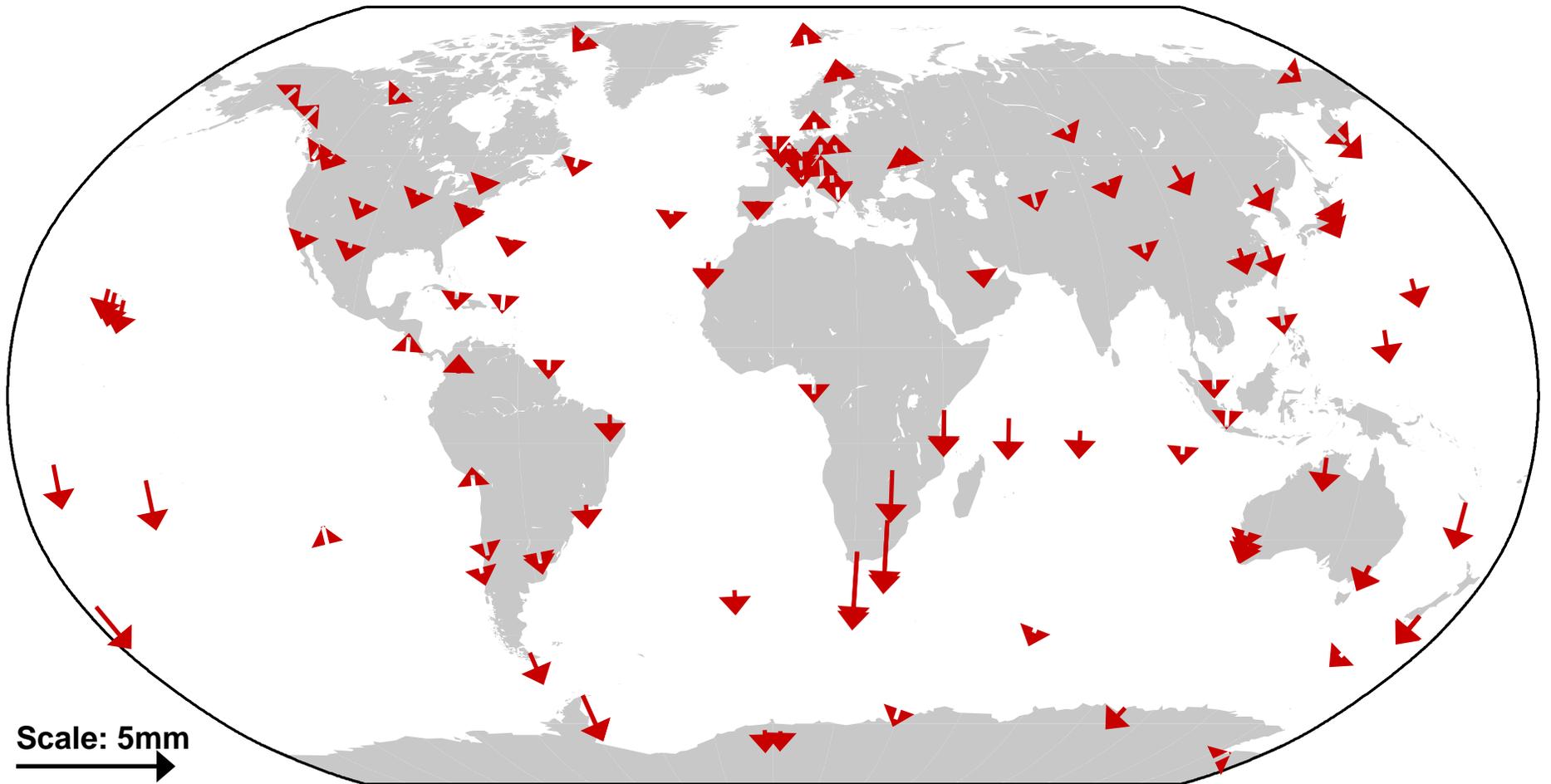
Bernese GPS Software (with NNR and NNT); week 1471; North component

Coordinate differences between “free orbit” and “default” solutions



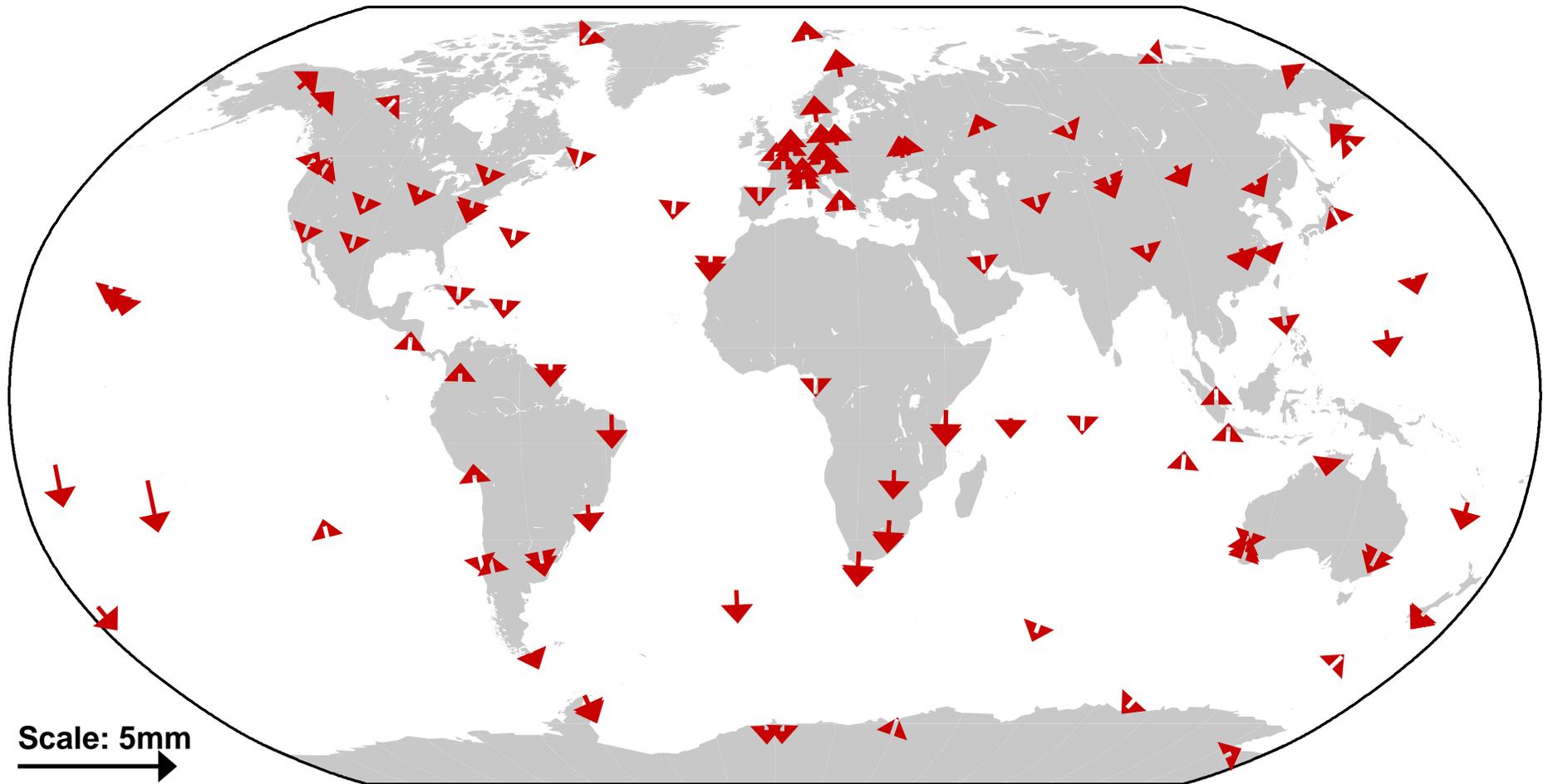
Bernese GPS Software (with NNR and NNT); week 1472; North component

Coordinate differences between “free orbit” and “default” solutions



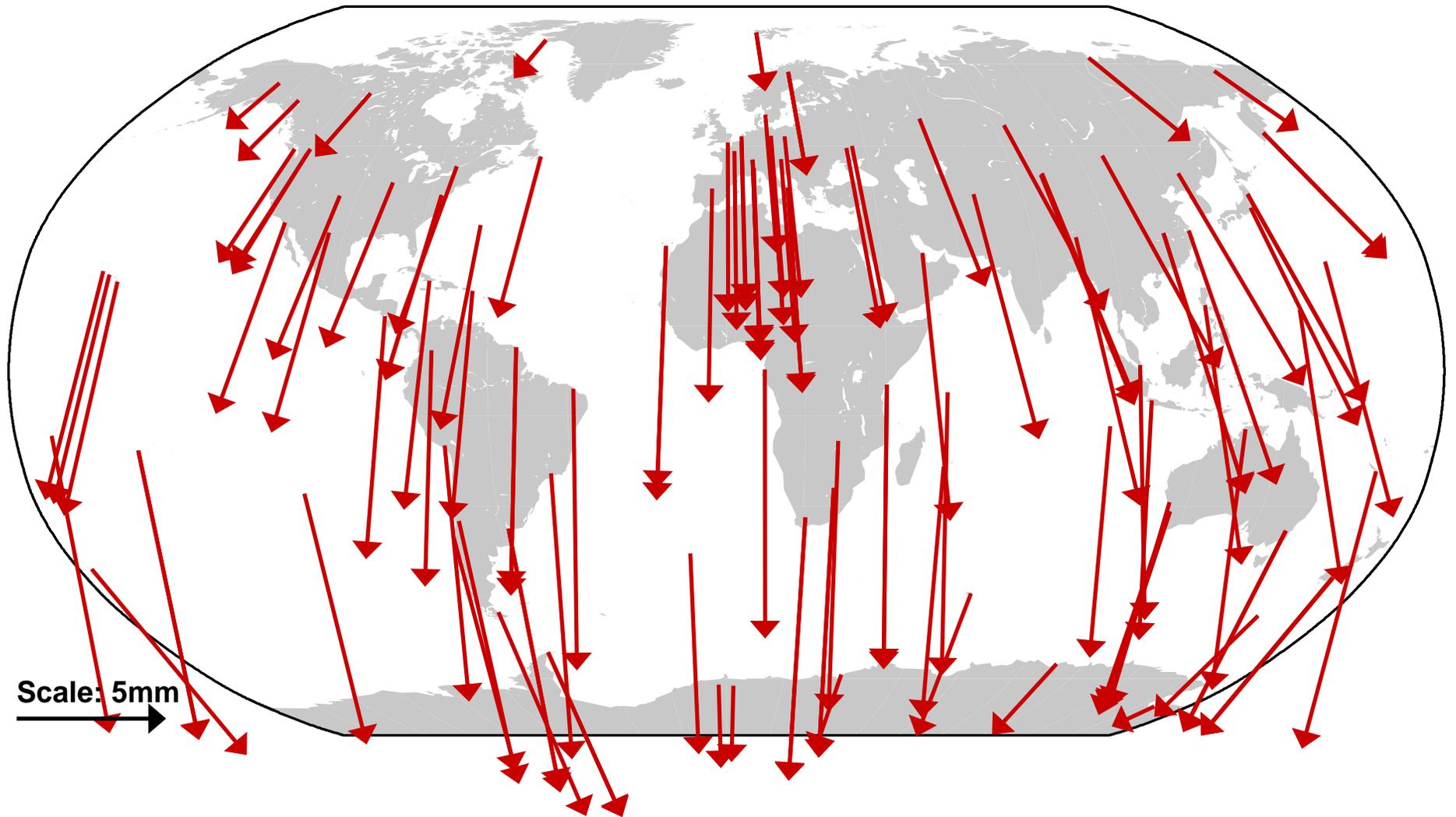
Bernese GPS Software (with NNR and NNT); week 1473; North component

Coordinate differences between “free orbit” and “default” solutions



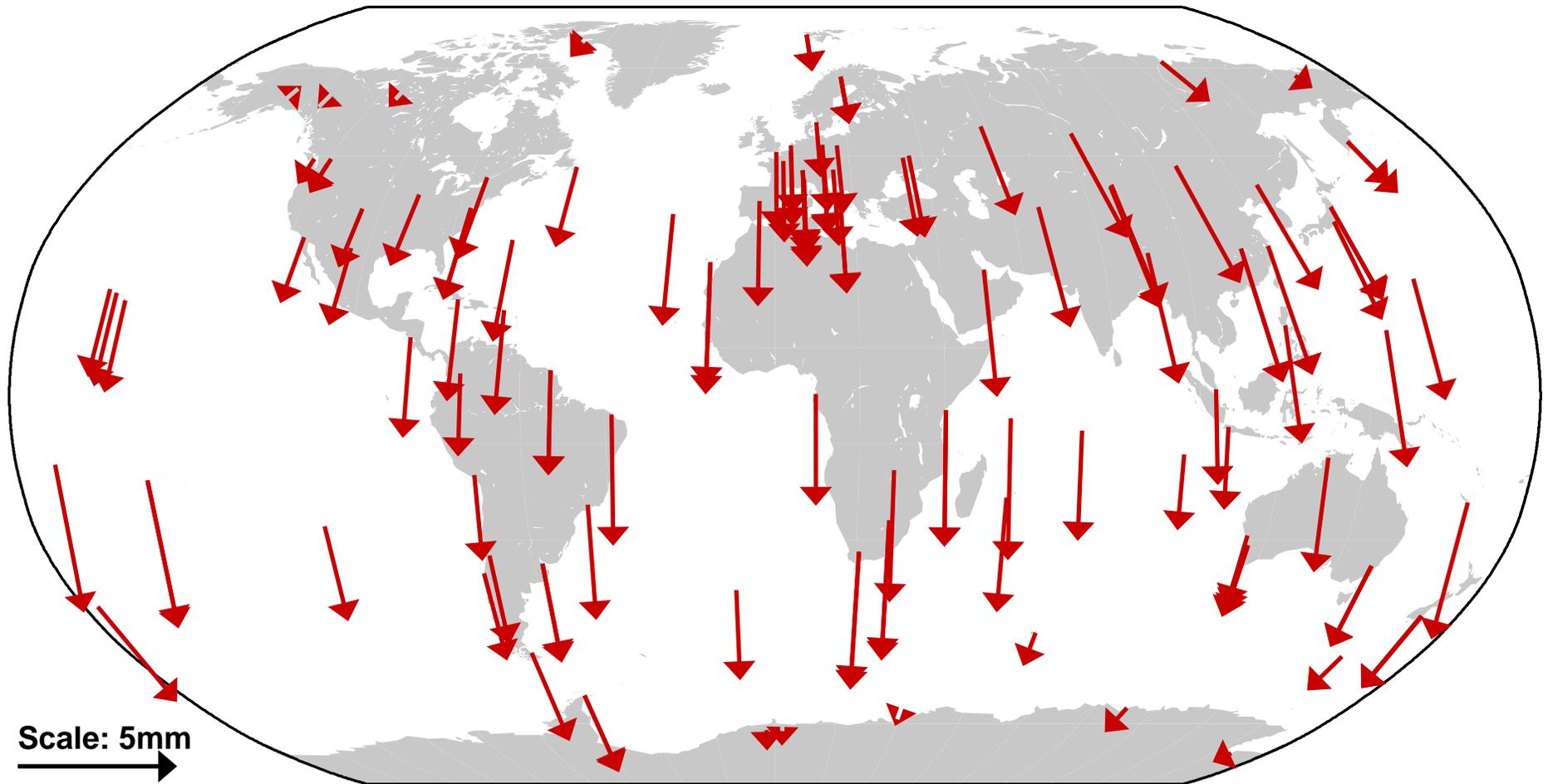
Bernese GPS Software (with NNR and NNT); week 1474; North component

Coordinate differences between “free orbit” and “default” solutions



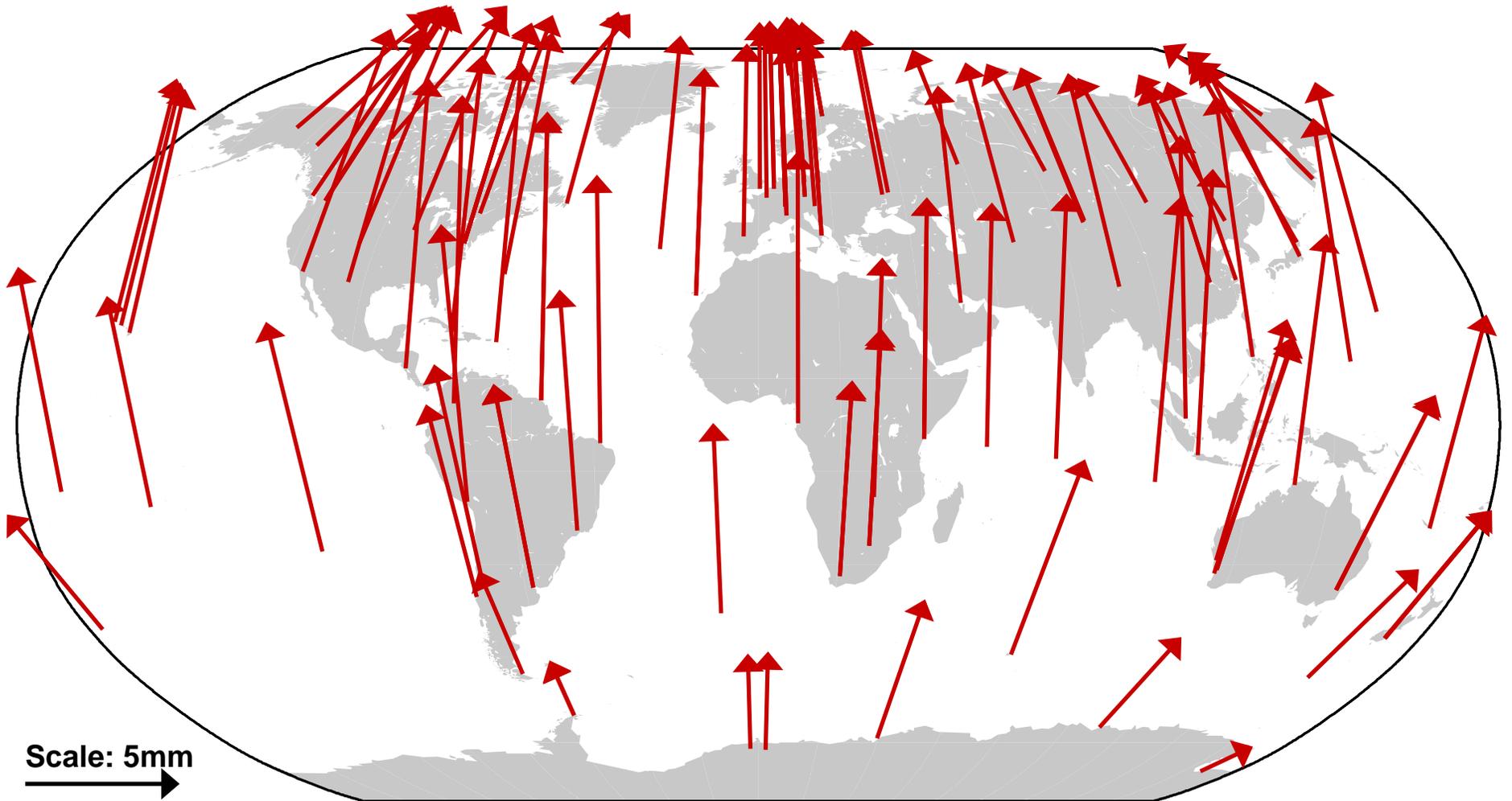
Bernese GPS Software (with NNR only); week 1471; North component

Coordinate differences between “free orbit” and “default” solutions



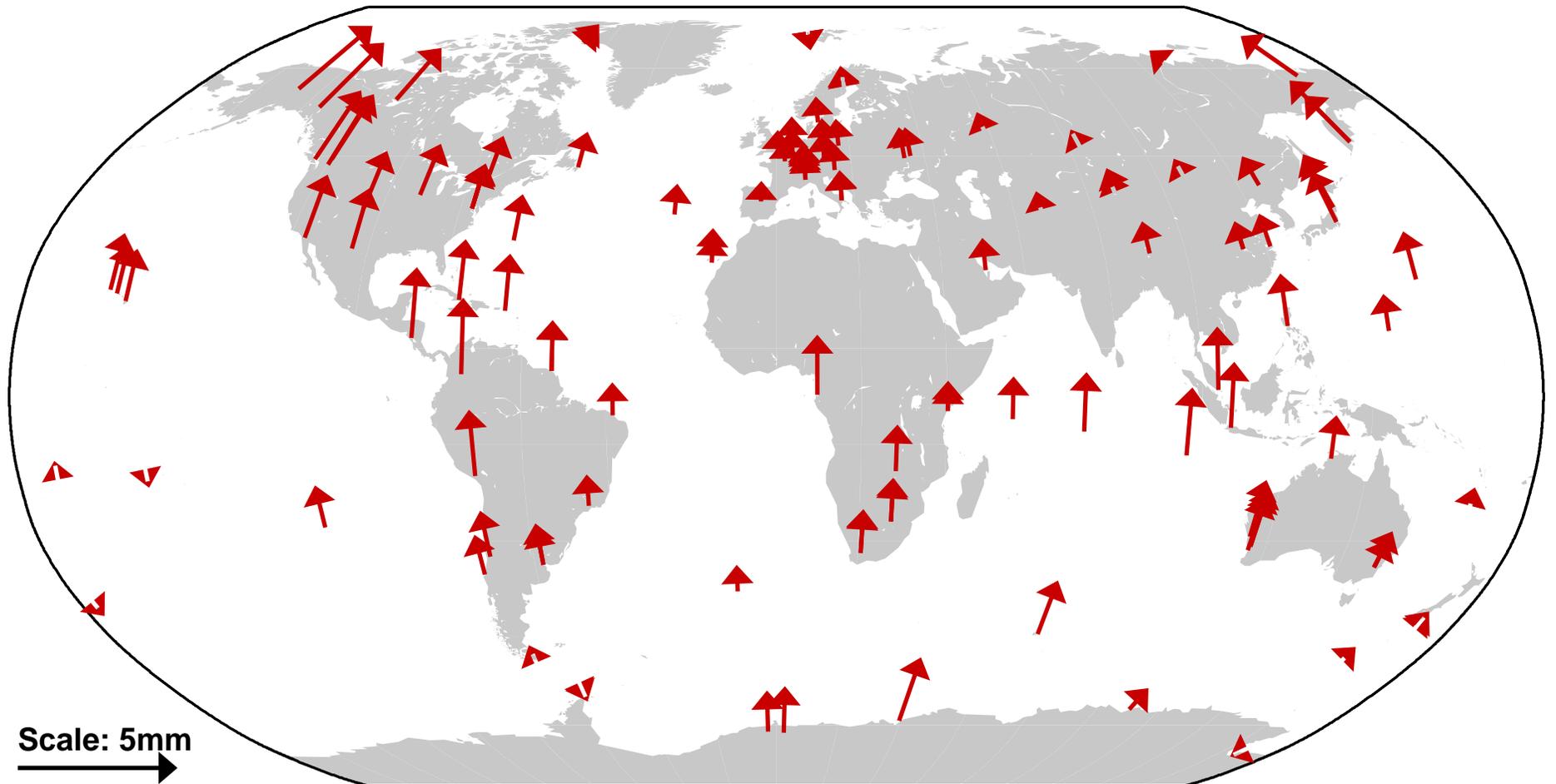
Bernese GPS Software (with NNR only); week 1472; North component

Coordinate differences between “free orbit” and “default” solutions



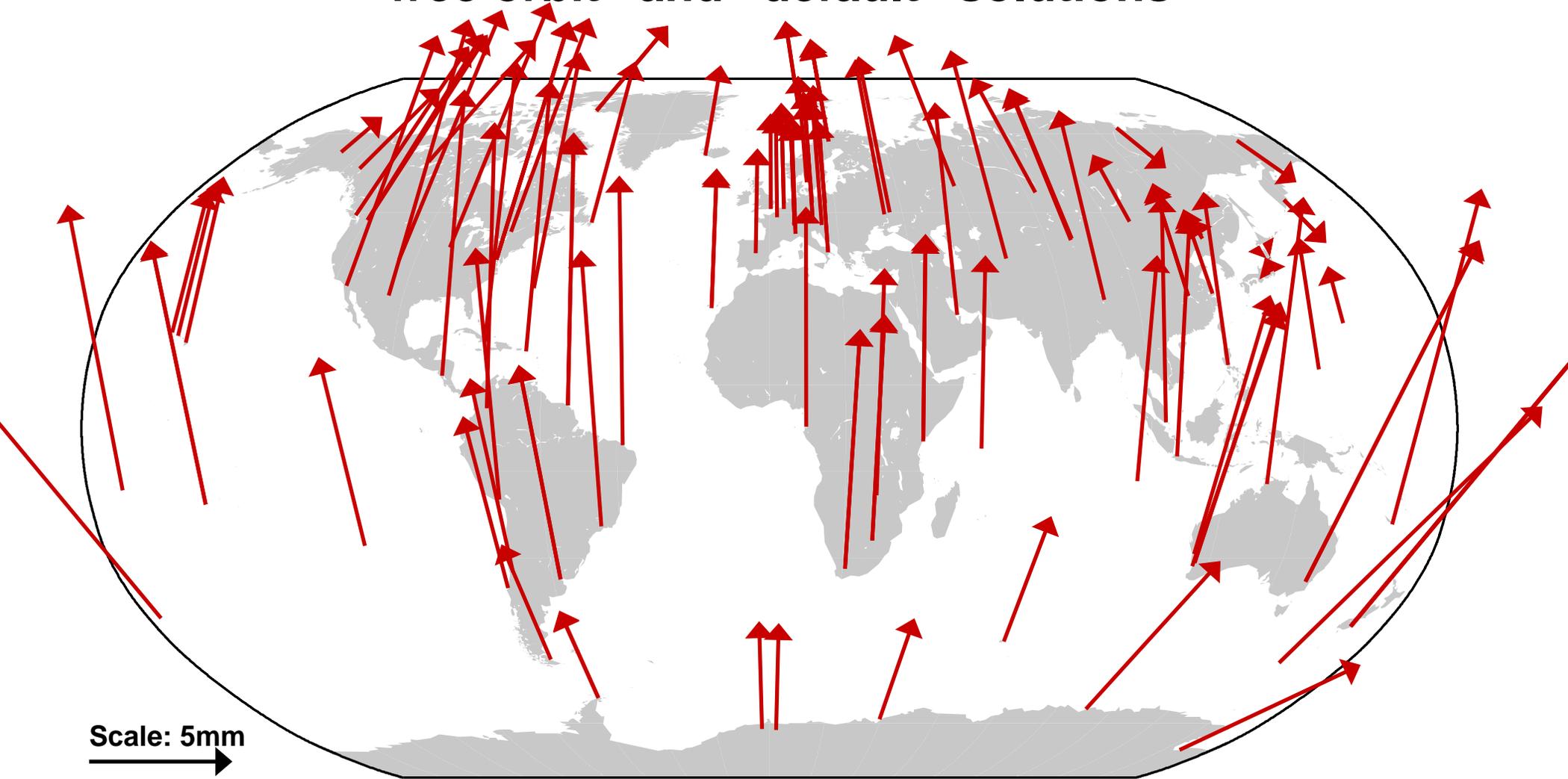
Bernese GPS Software (with NNR only); week 1473; North component

Coordinate differences between “free orbit” and “default” solutions



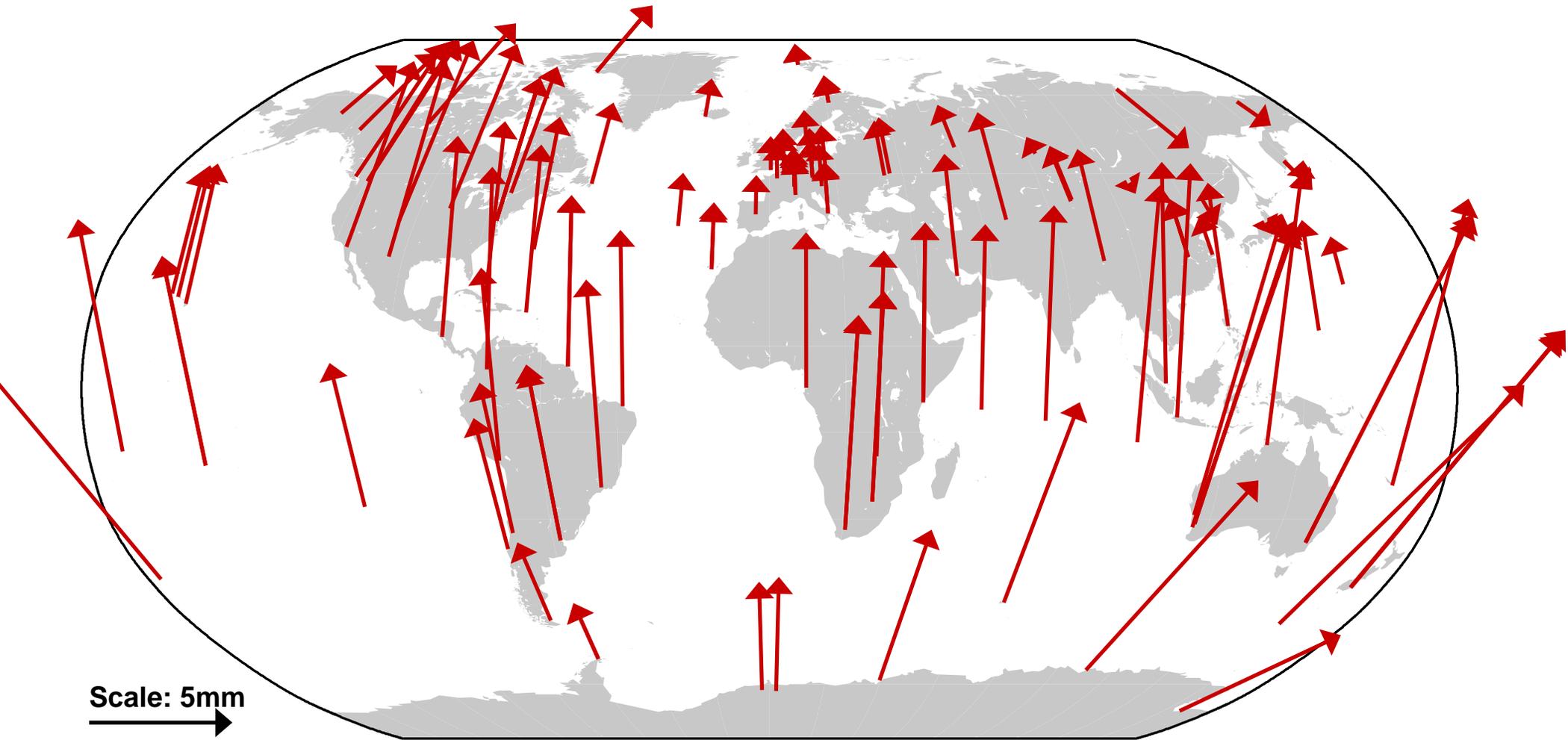
Bernese GPS Software (with NNR only); week 1474; North component

Coordinate differences between “free orbit” and “default” solutions



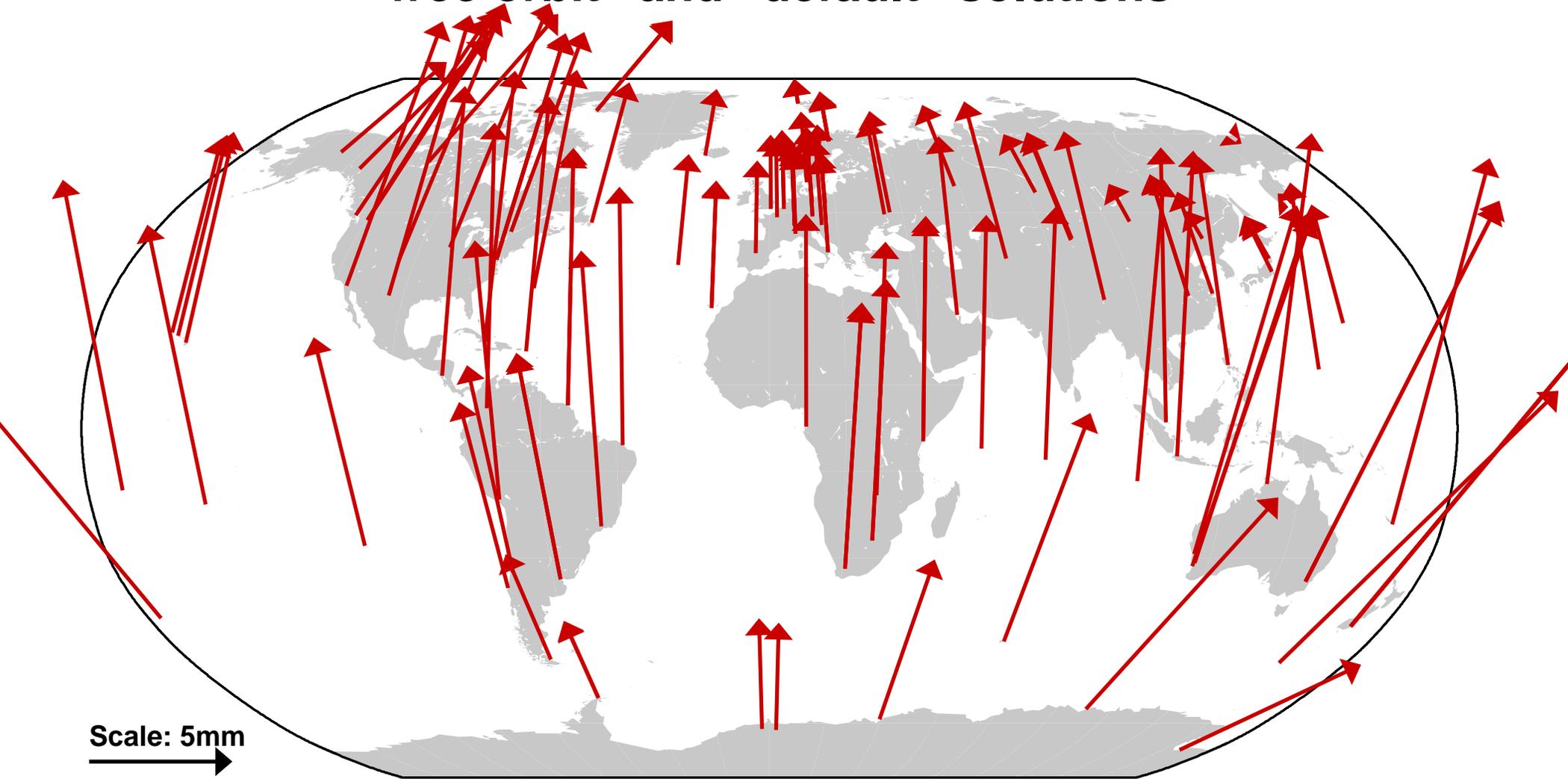
Napeos; week 1471; North component

Coordinate differences between “free orbit” and “default” solutions



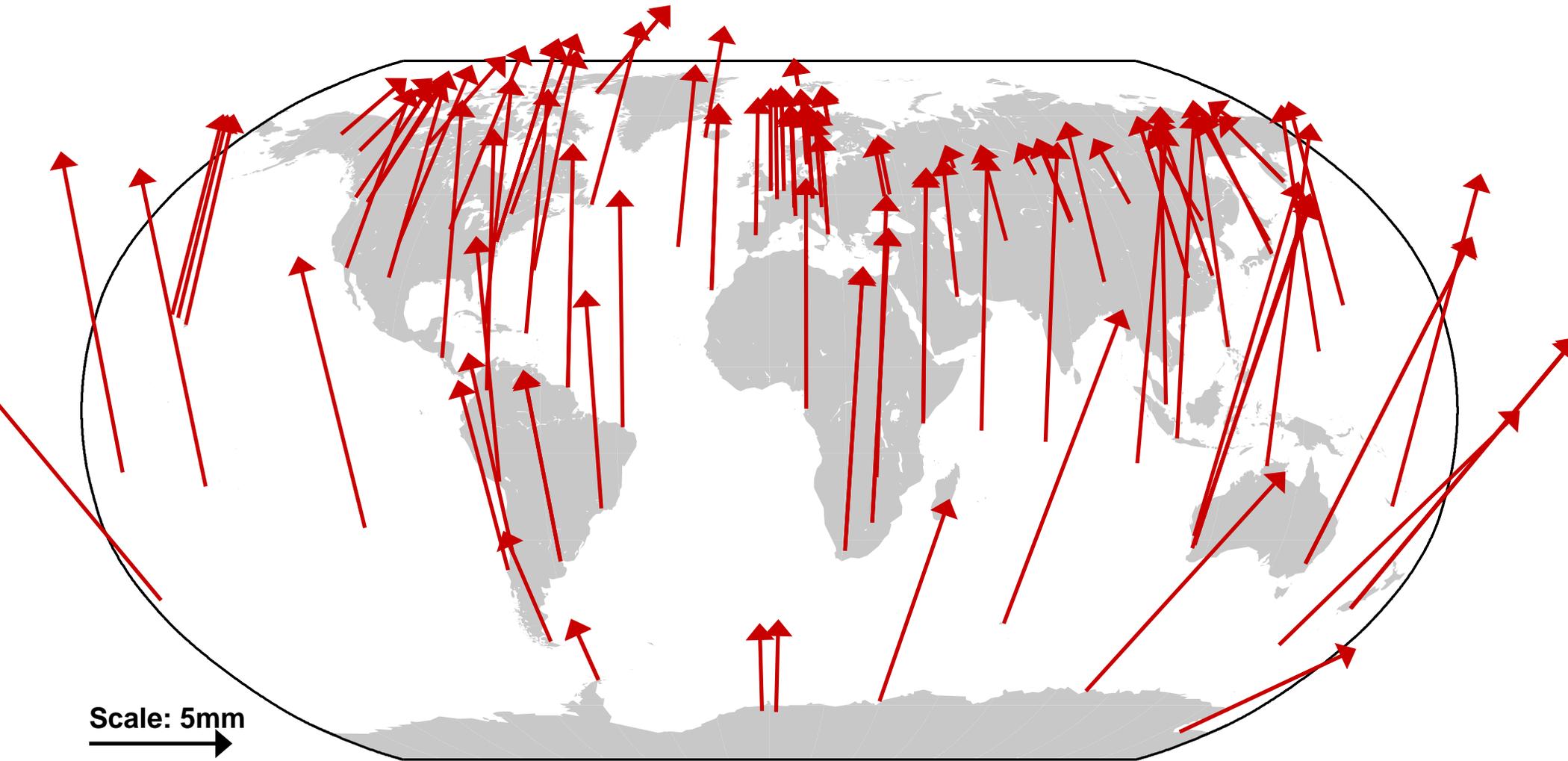
Napeos; week 1472; North component

Coordinate differences between “free orbit” and “default” solutions



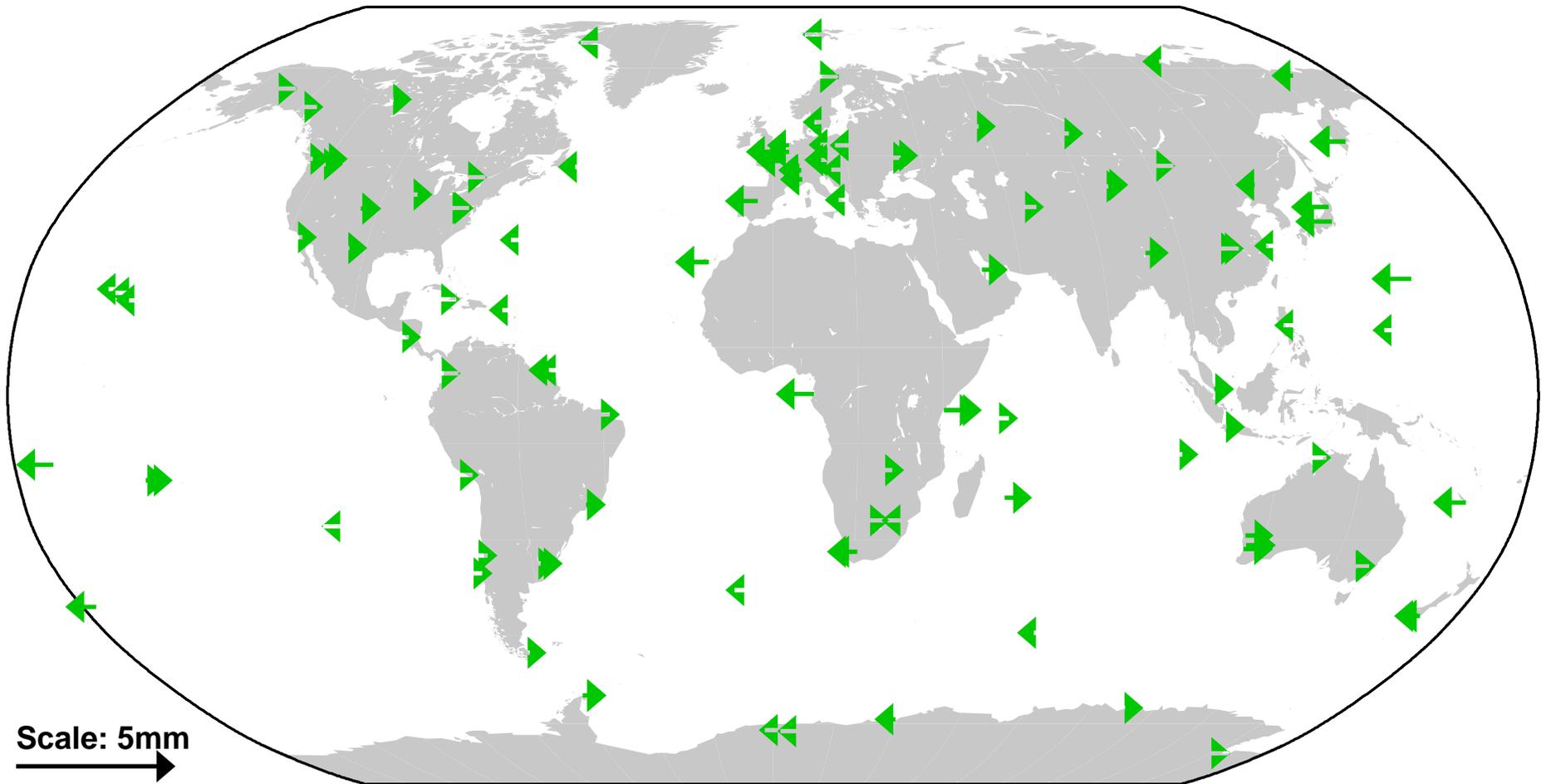
Napeos; week 1473; North component

Coordinate differences between “free orbit” and “default” solutions



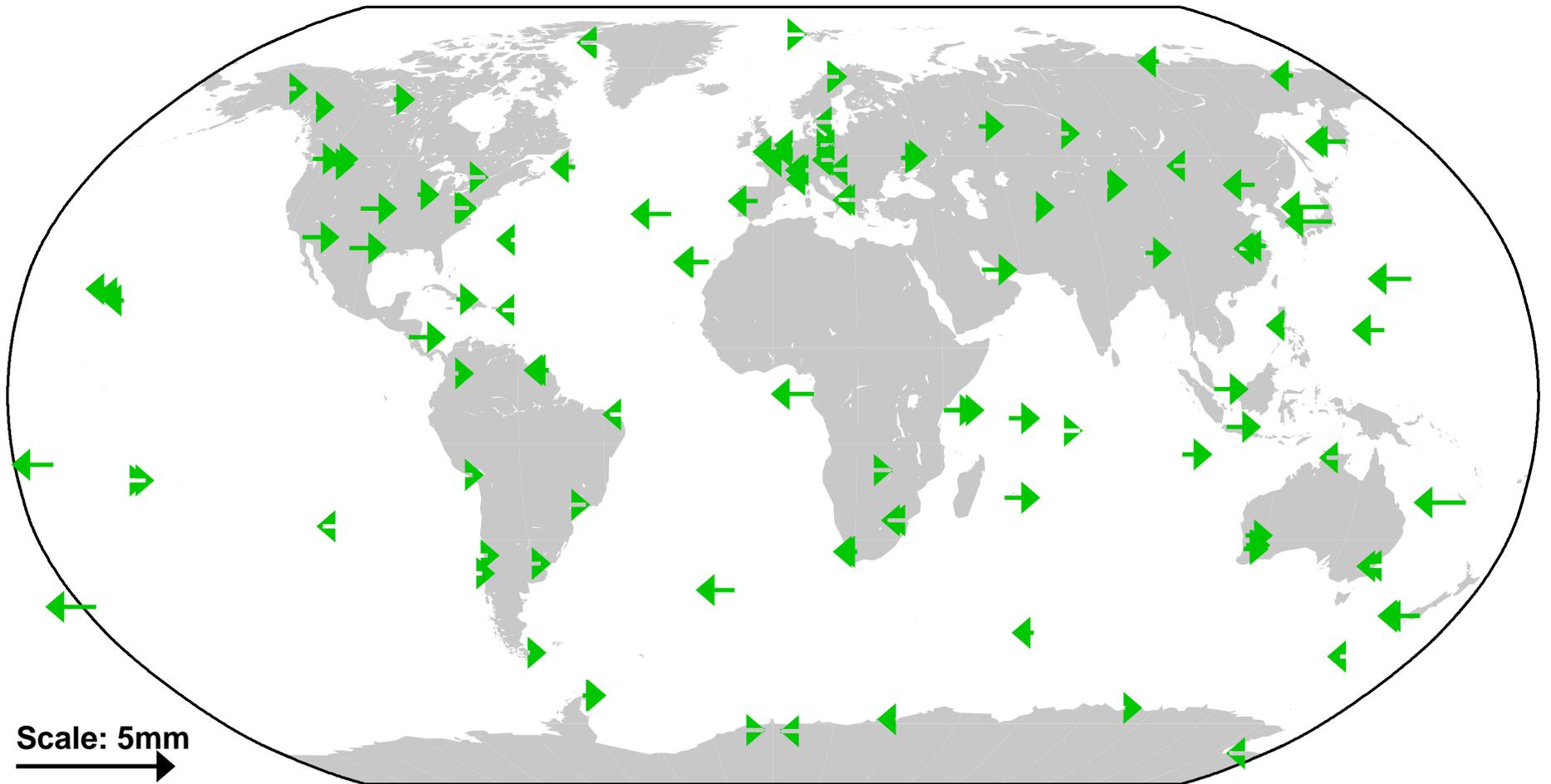
Napeos; week 1474; North component

Coordinate differences between “free orbit” and “default” solutions



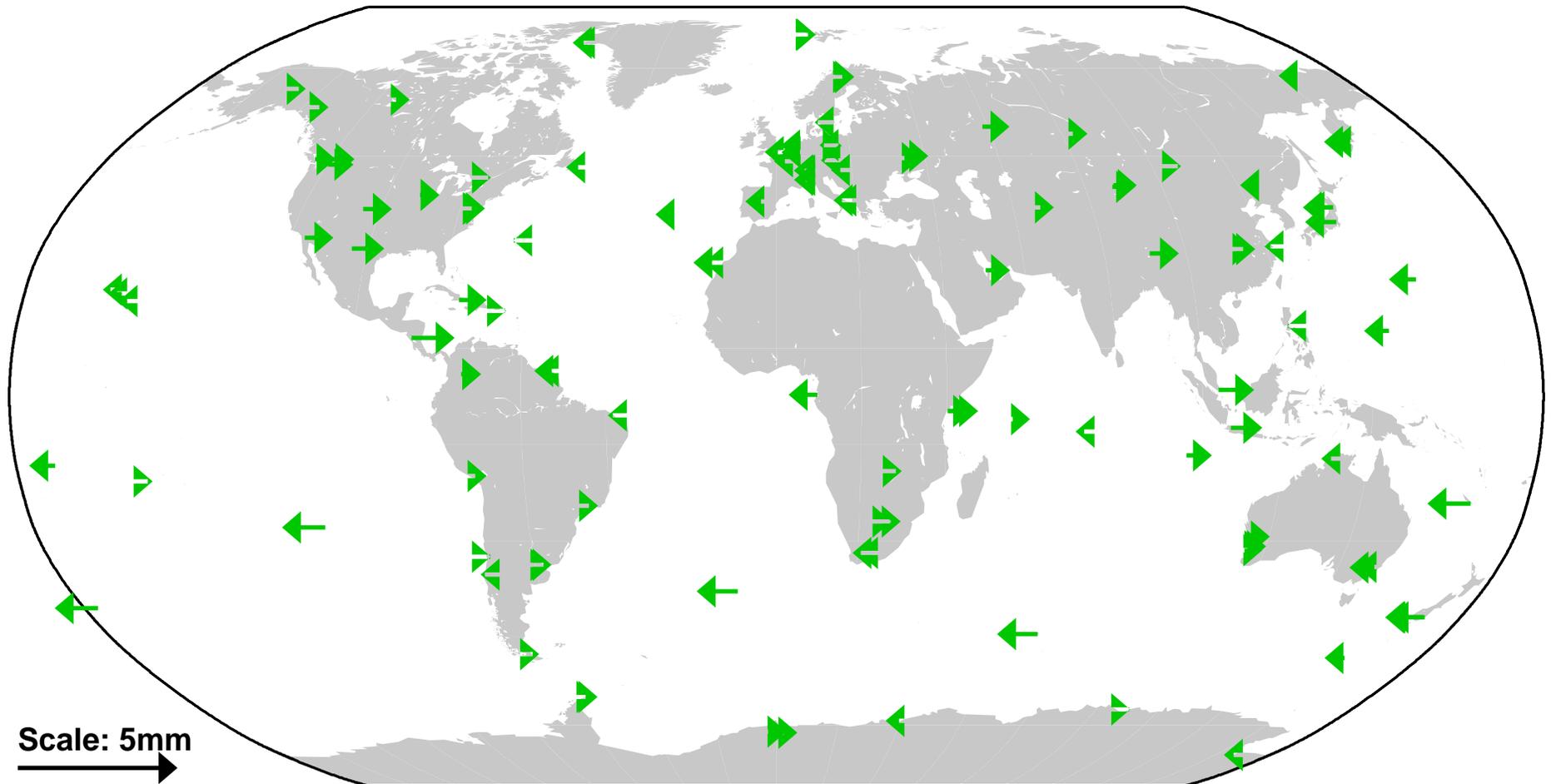
Bernese GPS Software (with NNR and NNT); week 1471; East component

Coordinate differences between “free orbit” and “default” solutions



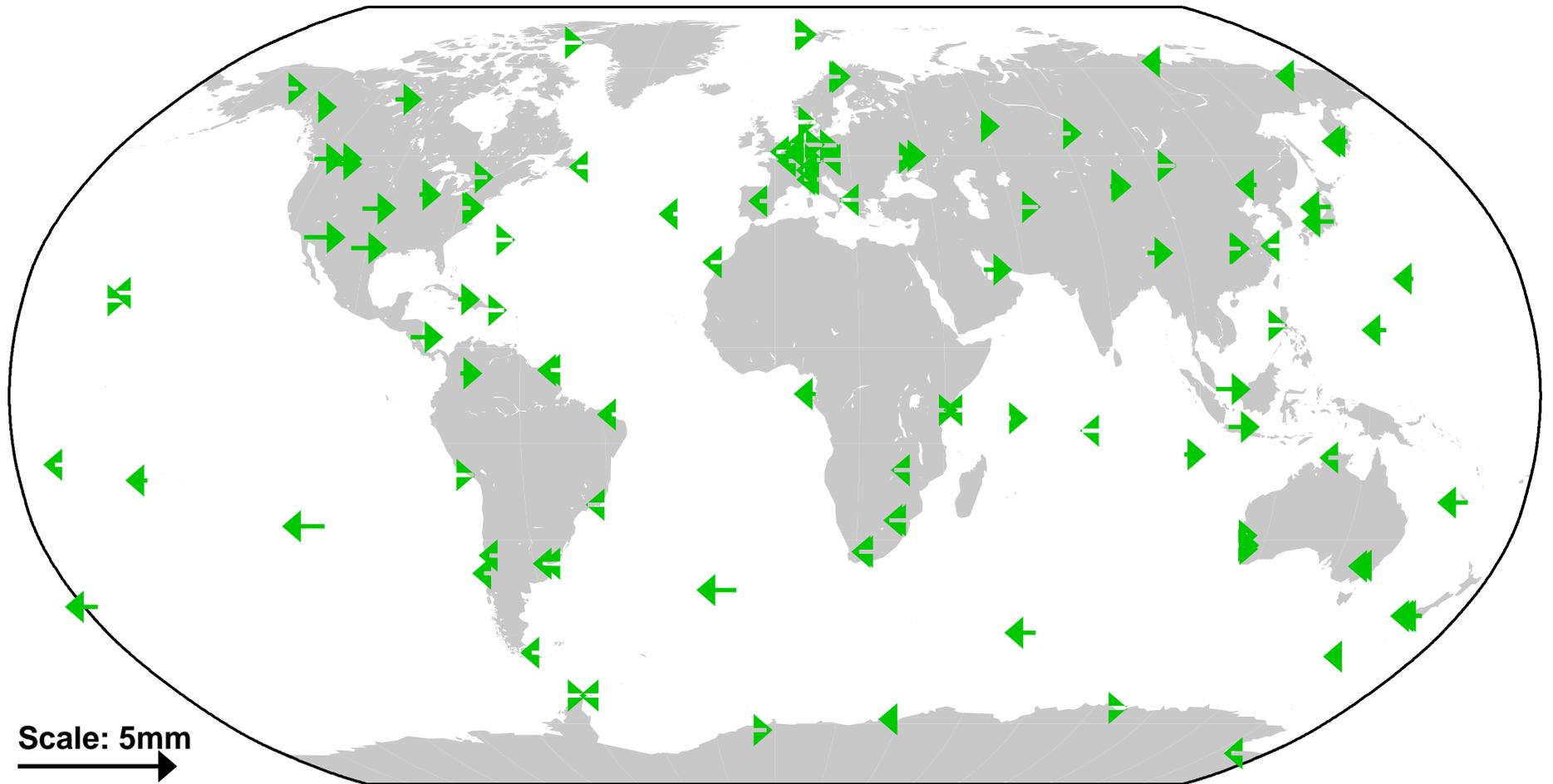
Bernese GPS Software (with NNR and NNT); week 1472; East component

Coordinate differences between “free orbit” and “default” solutions



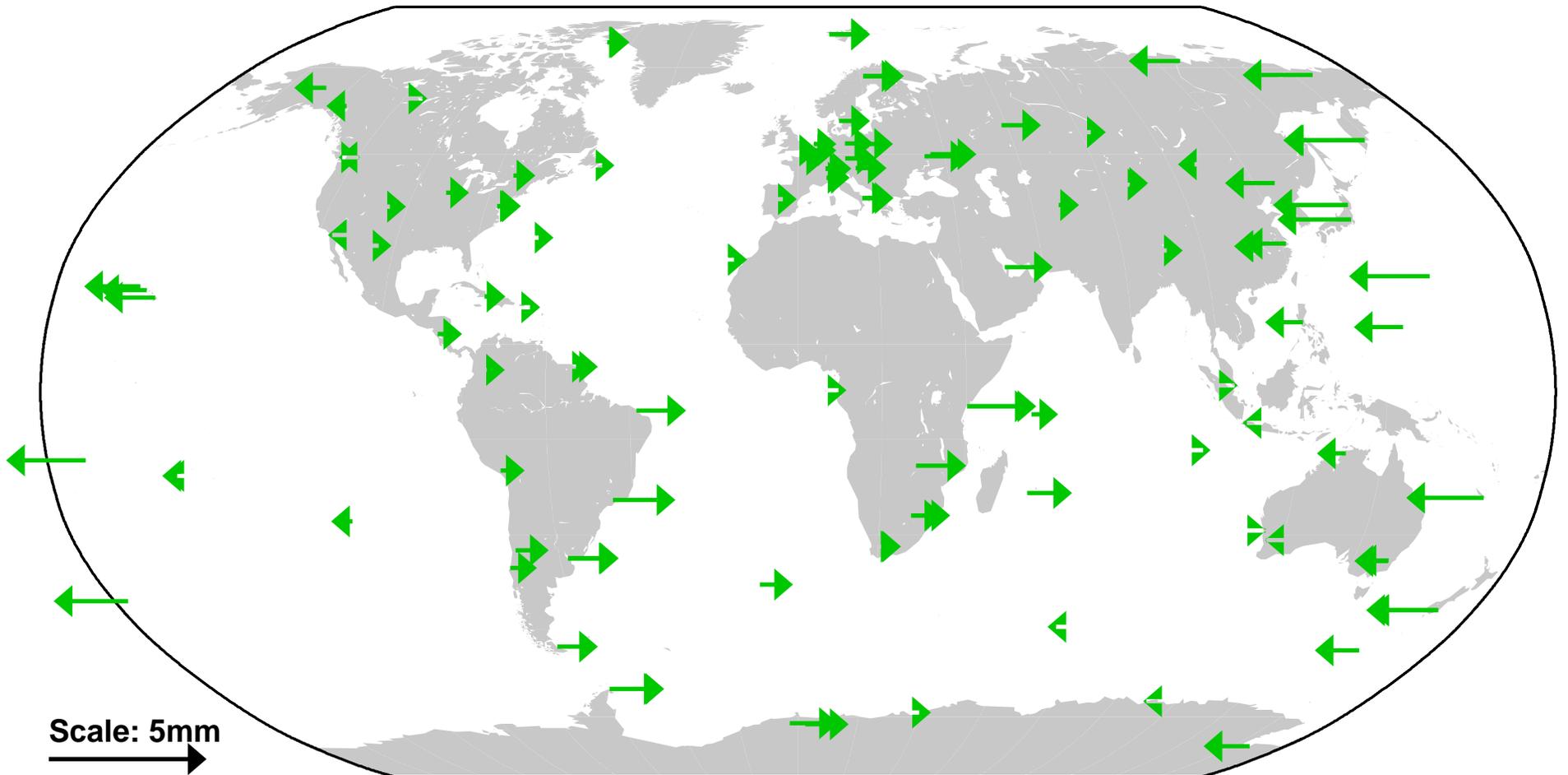
Bernese GPS Software (with NNR and NNT); week 1473; East component

Coordinate differences between “free orbit” and “default” solutions



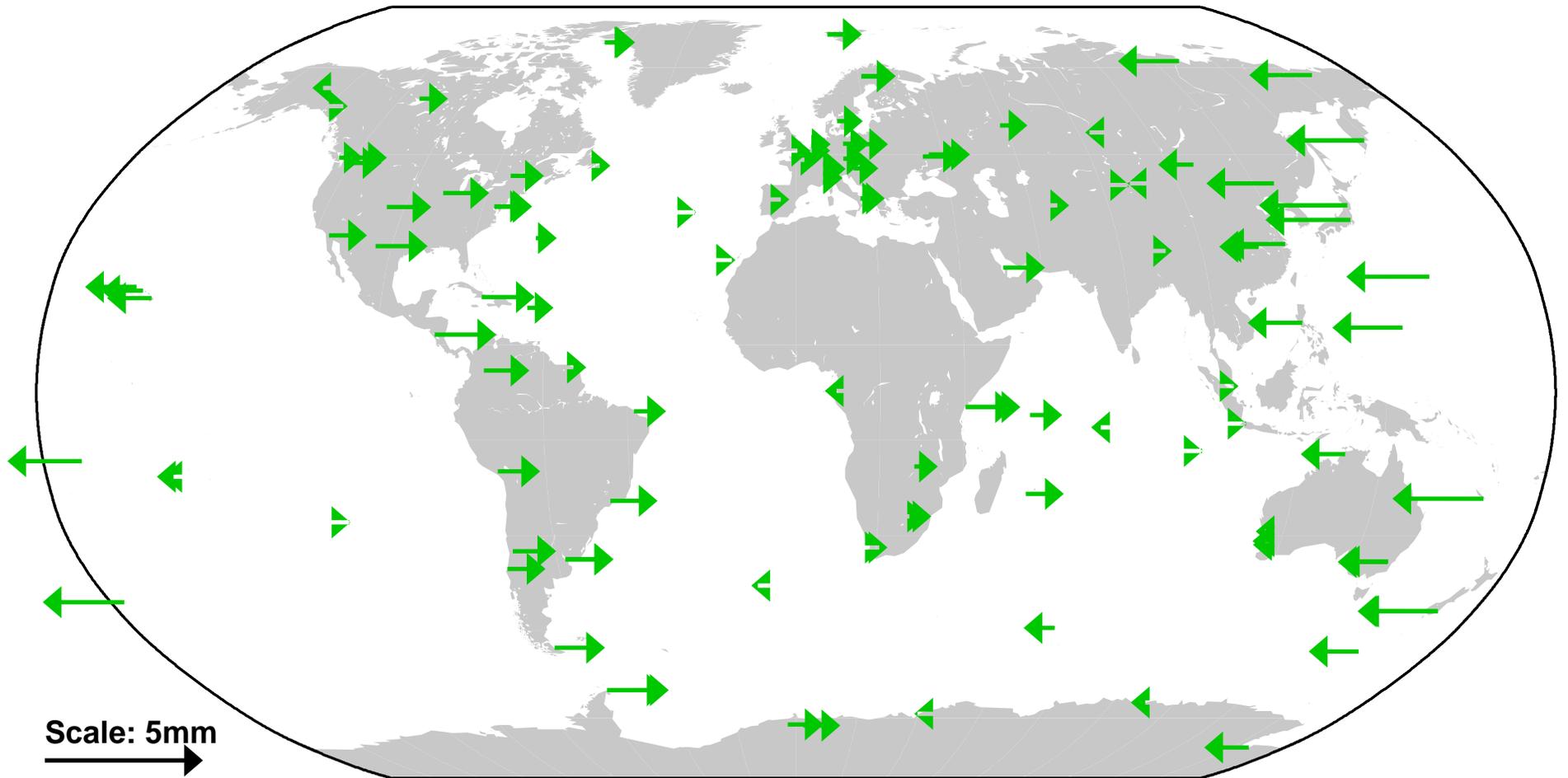
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Coordinate differences between “free orbit” and “default” solutions



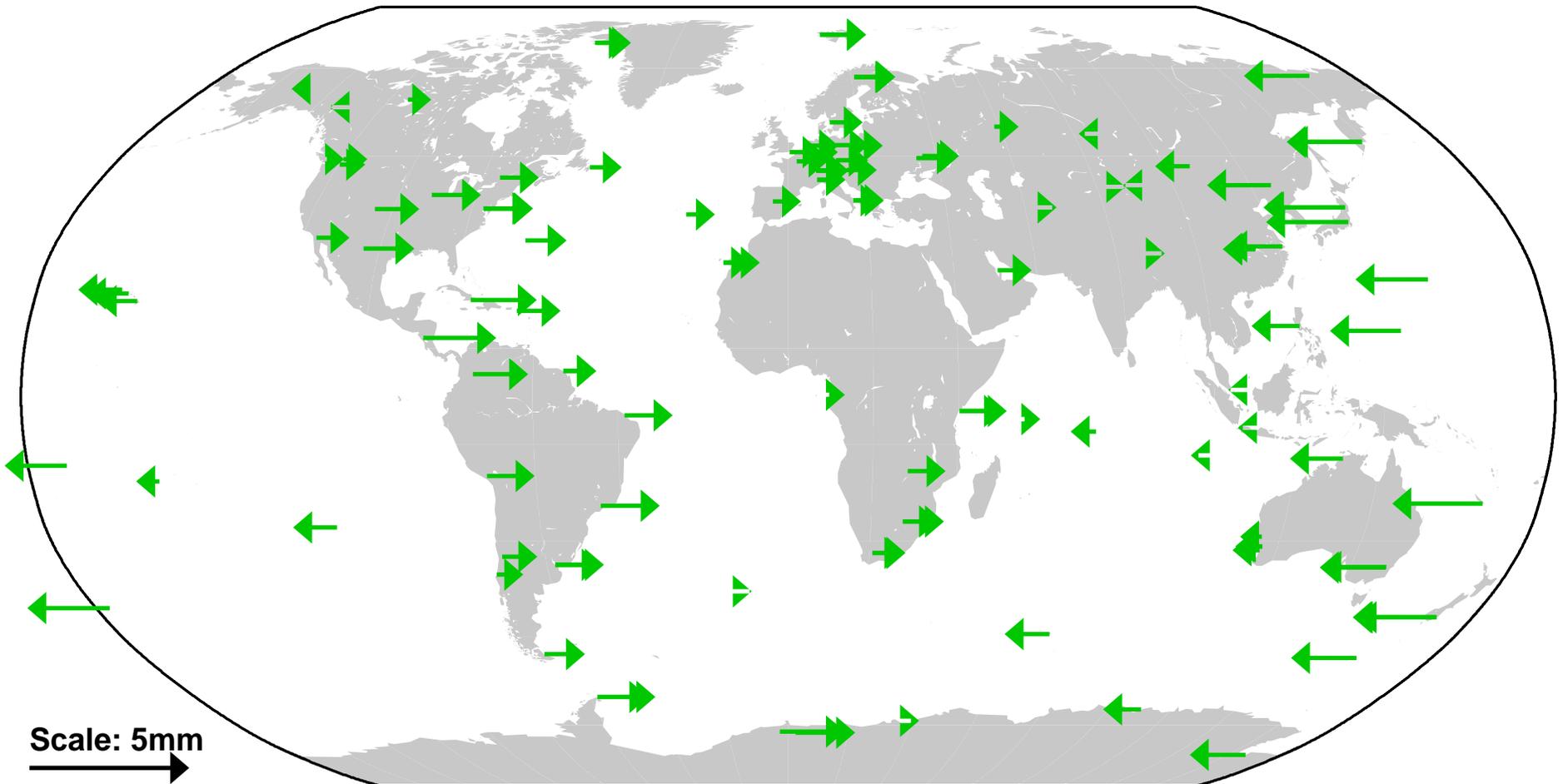
Bernese GPS Software (with NNR only); week 1471; East component

Coordinate differences between “free orbit” and “default” solutions



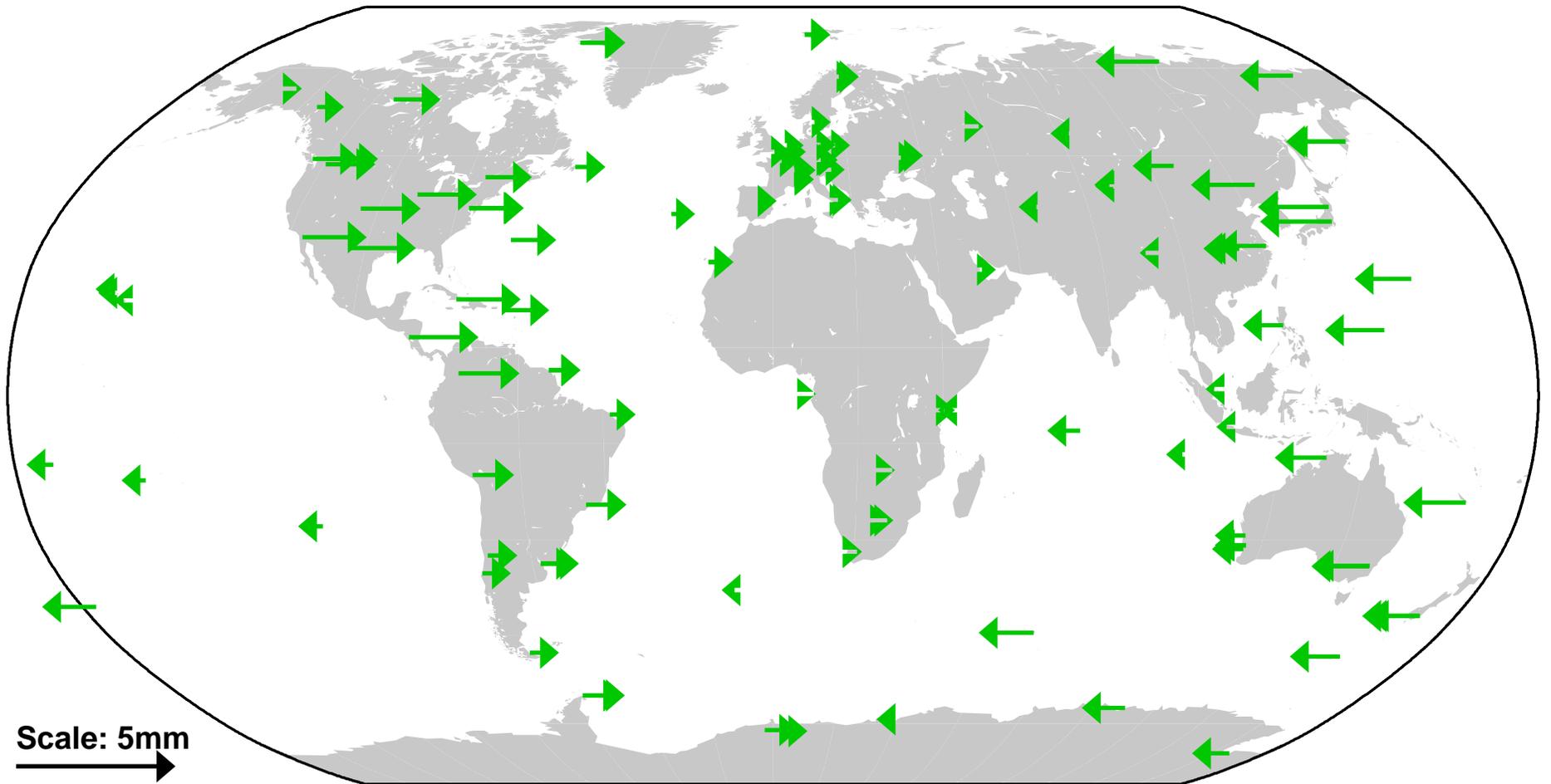
Bernese GPS Software (with NNR only); week 1472; East component

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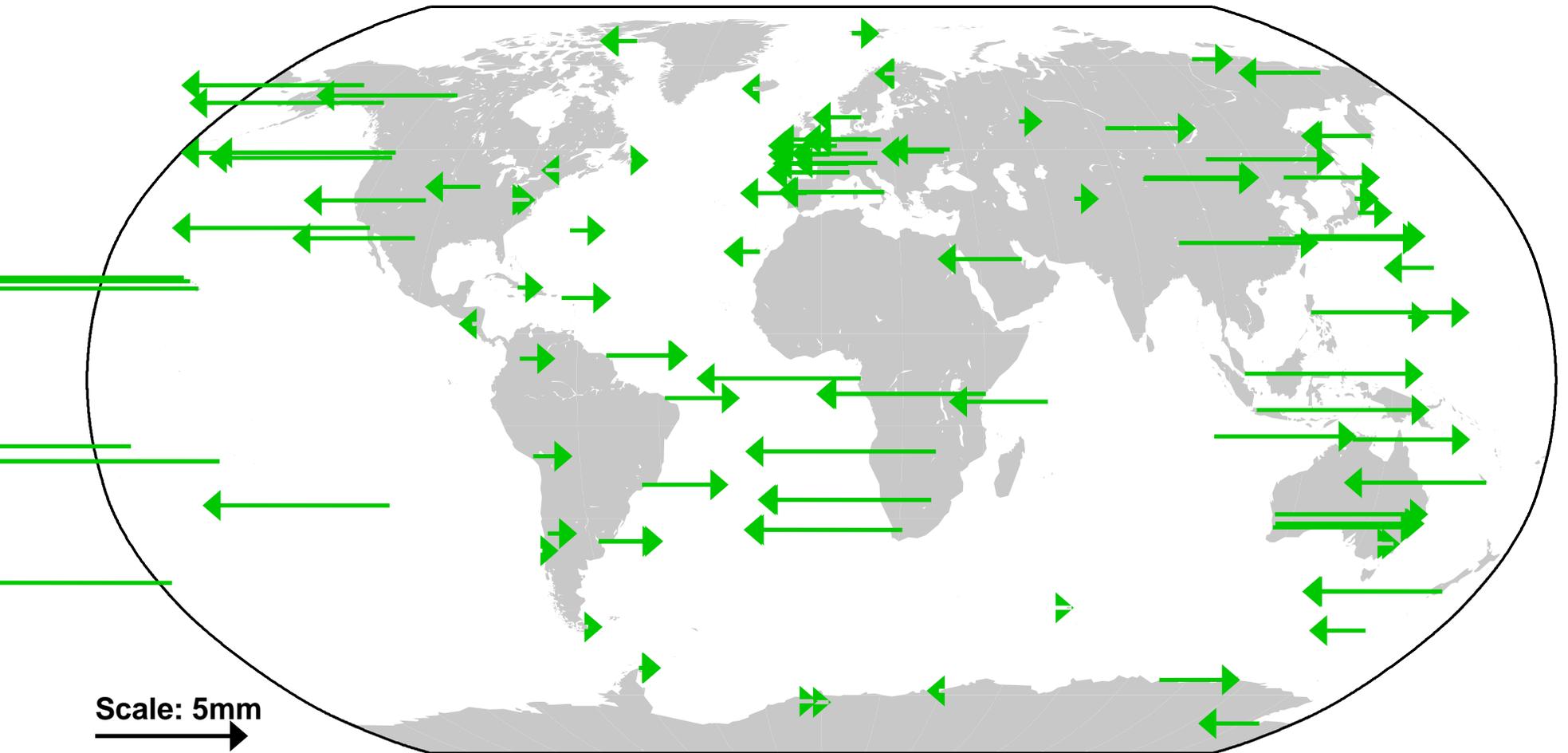
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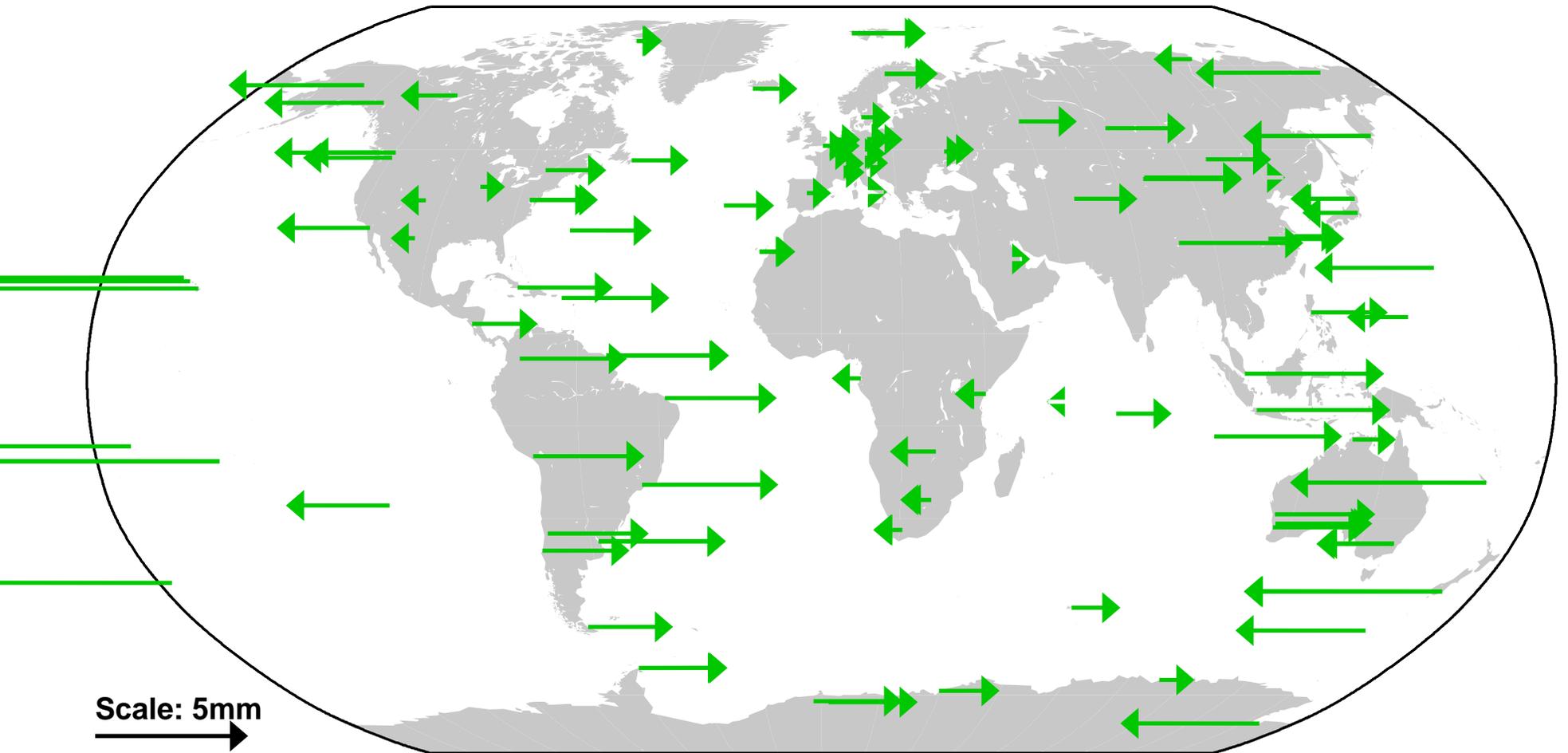
Bernese GPS Software (with NNR only); week 1474; East component

Coordinate differences between “free orbit” and “default” solutions



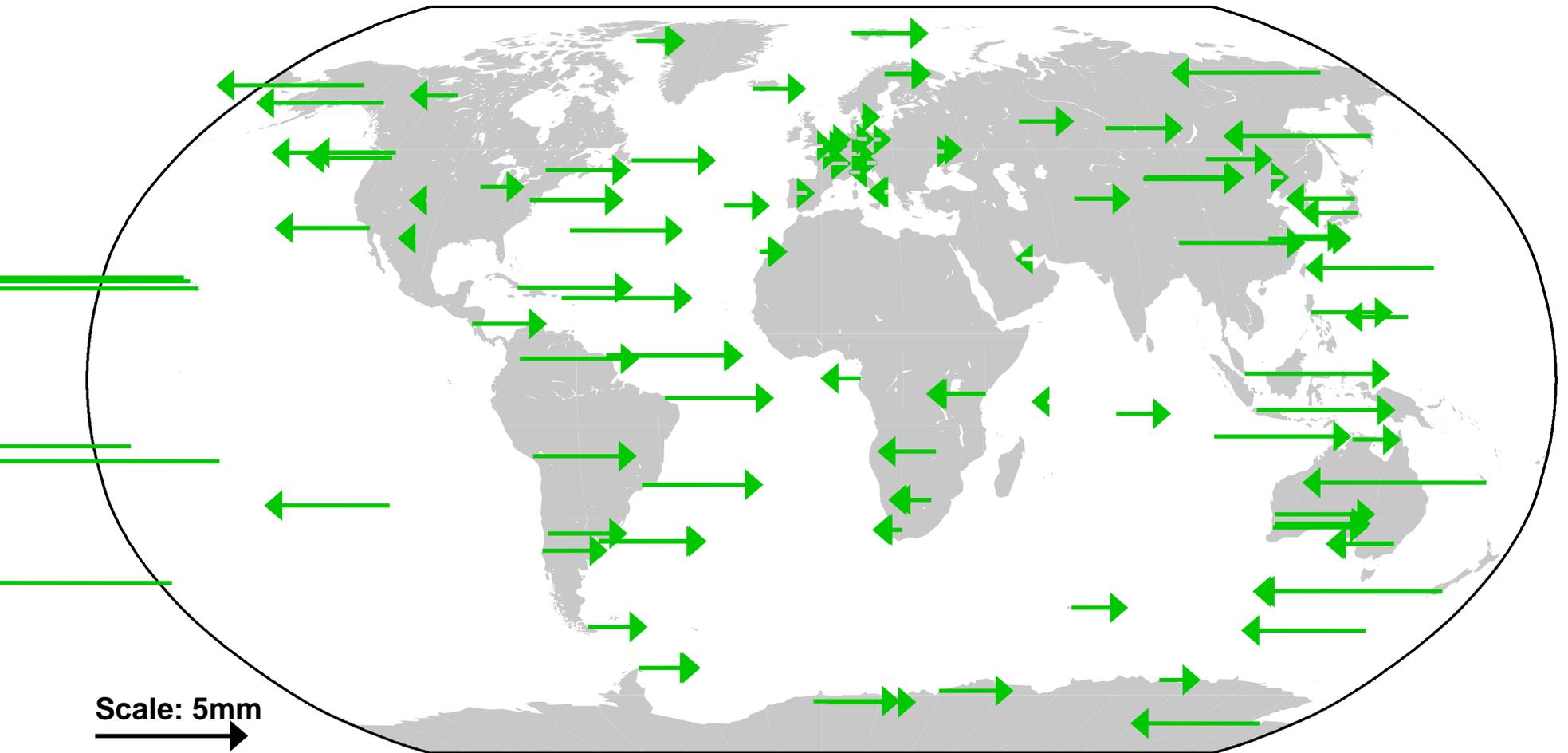
Napeos; week 1471; East component

Coordinate differences between “free orbit” and “default” solutions



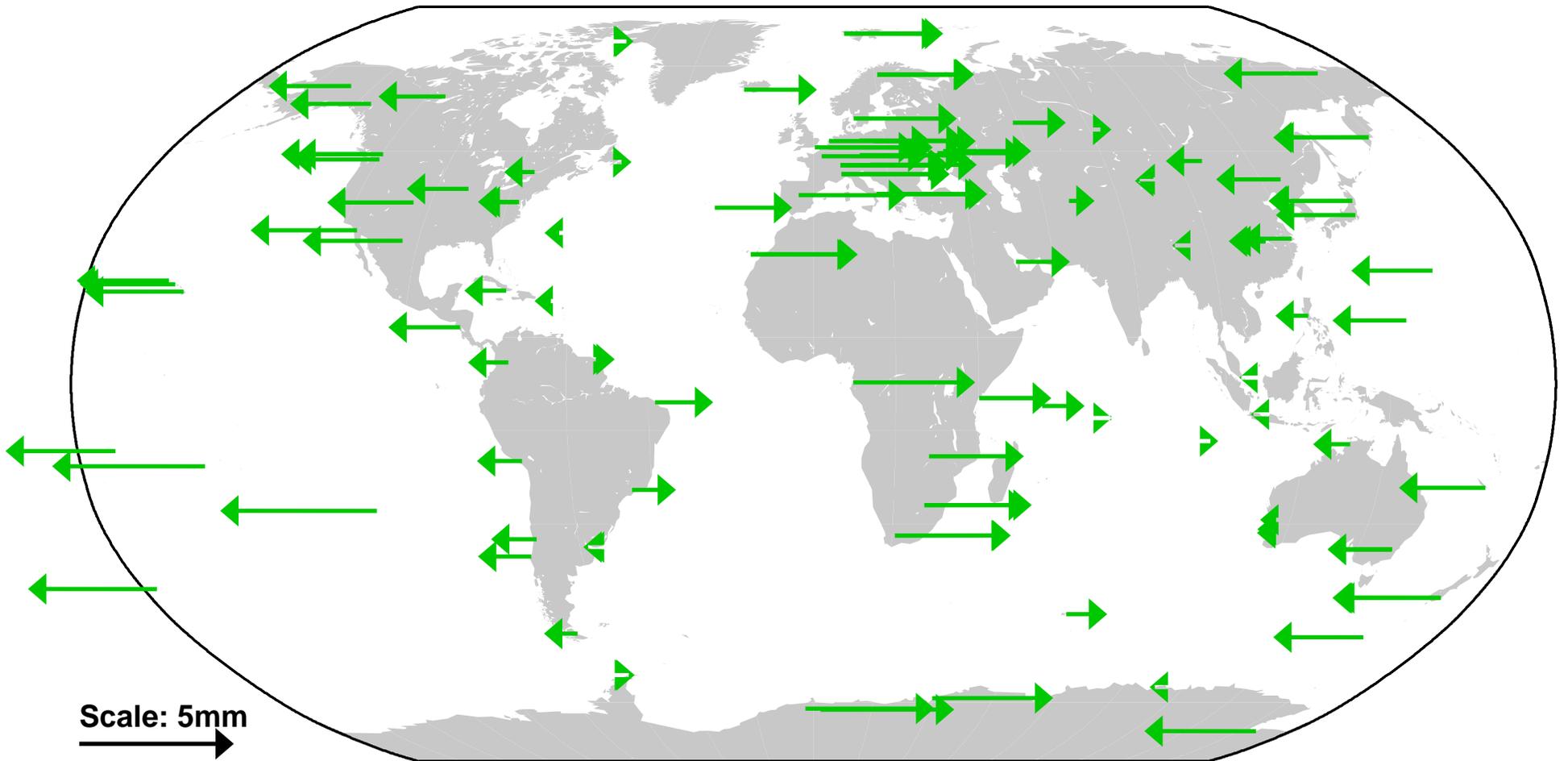
Napeos; week 1472; East component

Coordinate differences between “free orbit” and “default” solutions



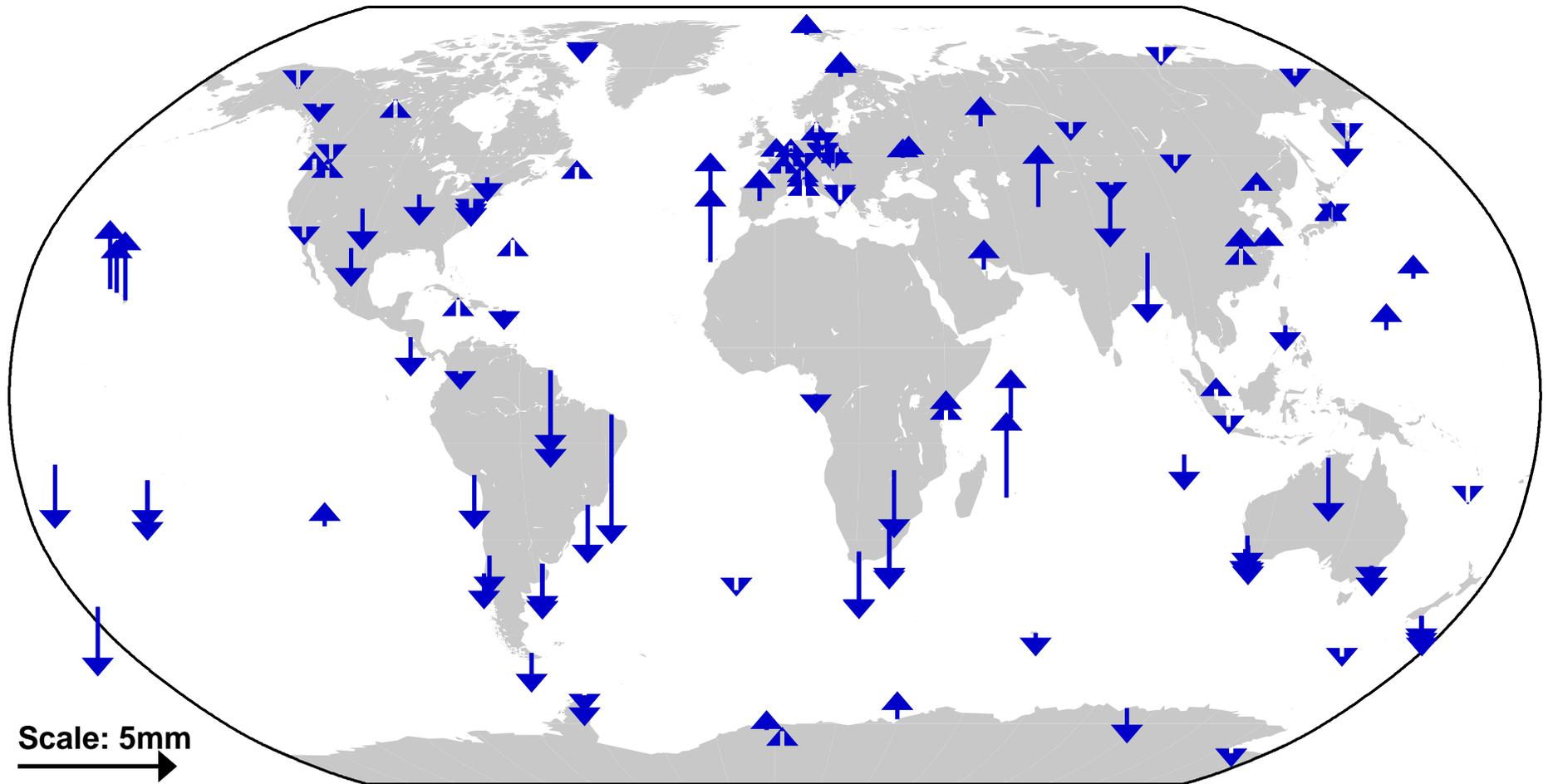
Napeos; week 1473; East component

Coordinate differences between “free orbit” and “default” solutions



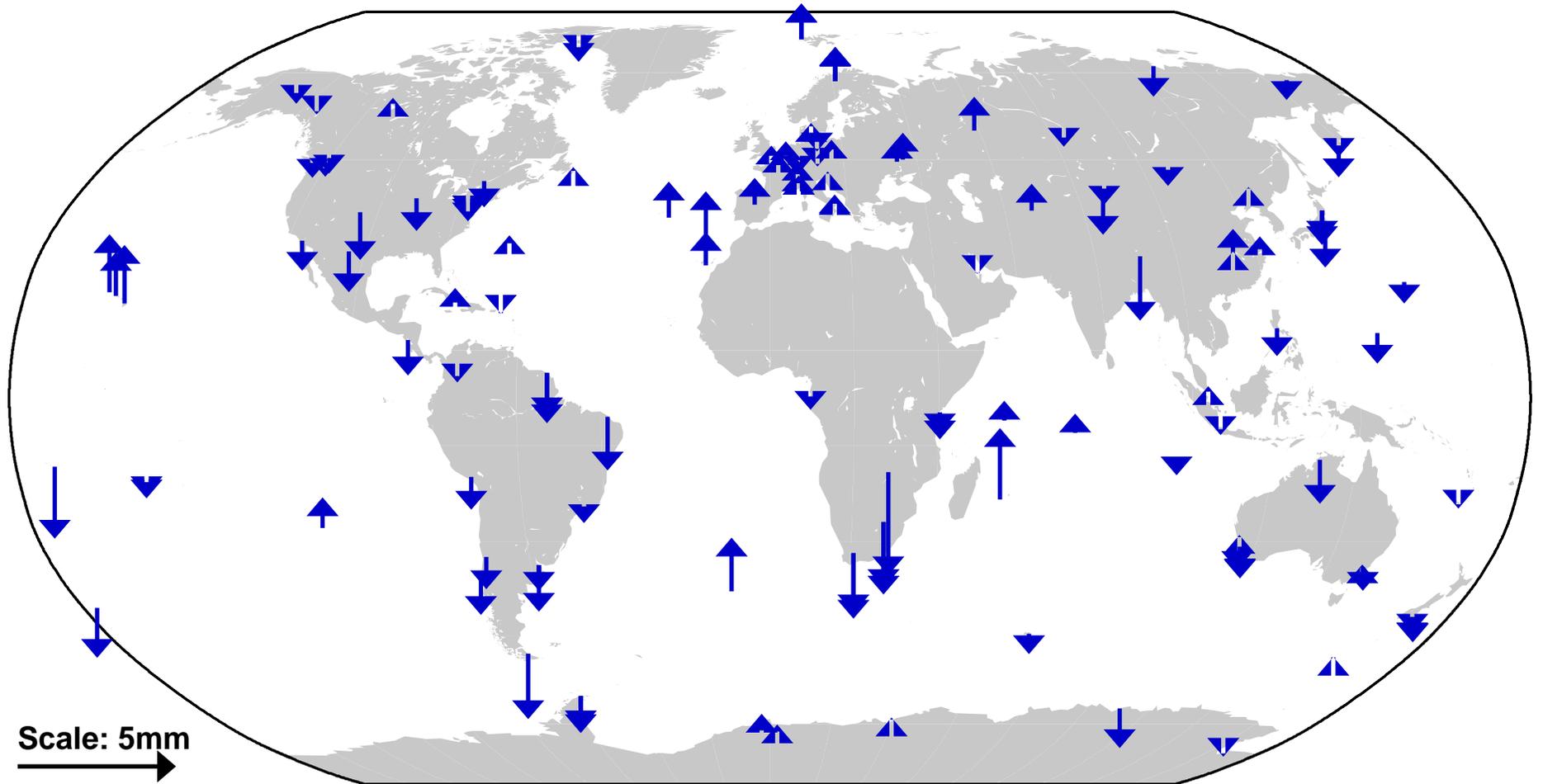
Napeos; week 1474; East component

Coordinate differences between “free orbit” and “default” solutions



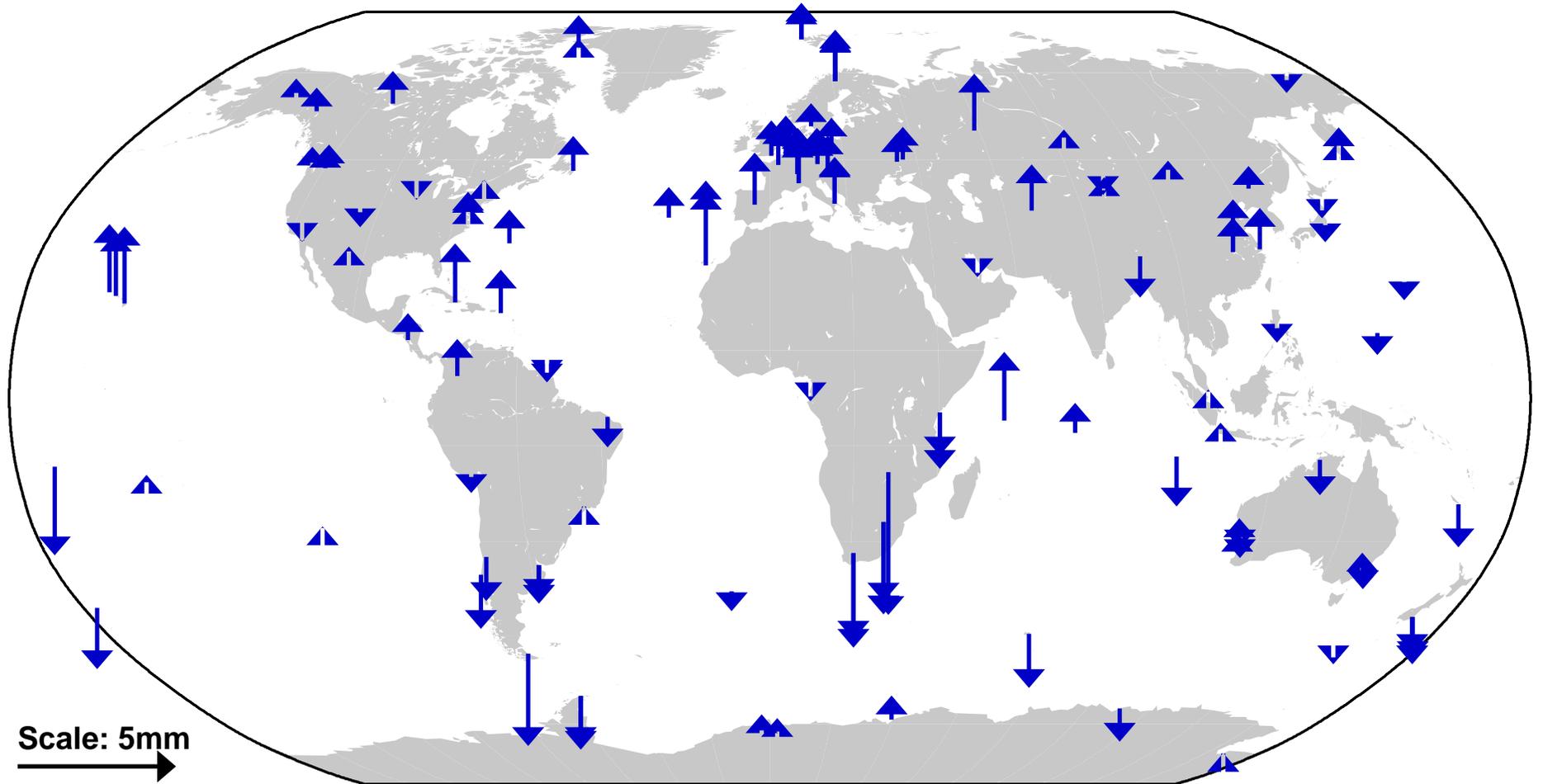
Bernese GPS Software (with NNR and NNT); week 1471; Up component

Coordinate differences between “free orbit” and “default” solutions



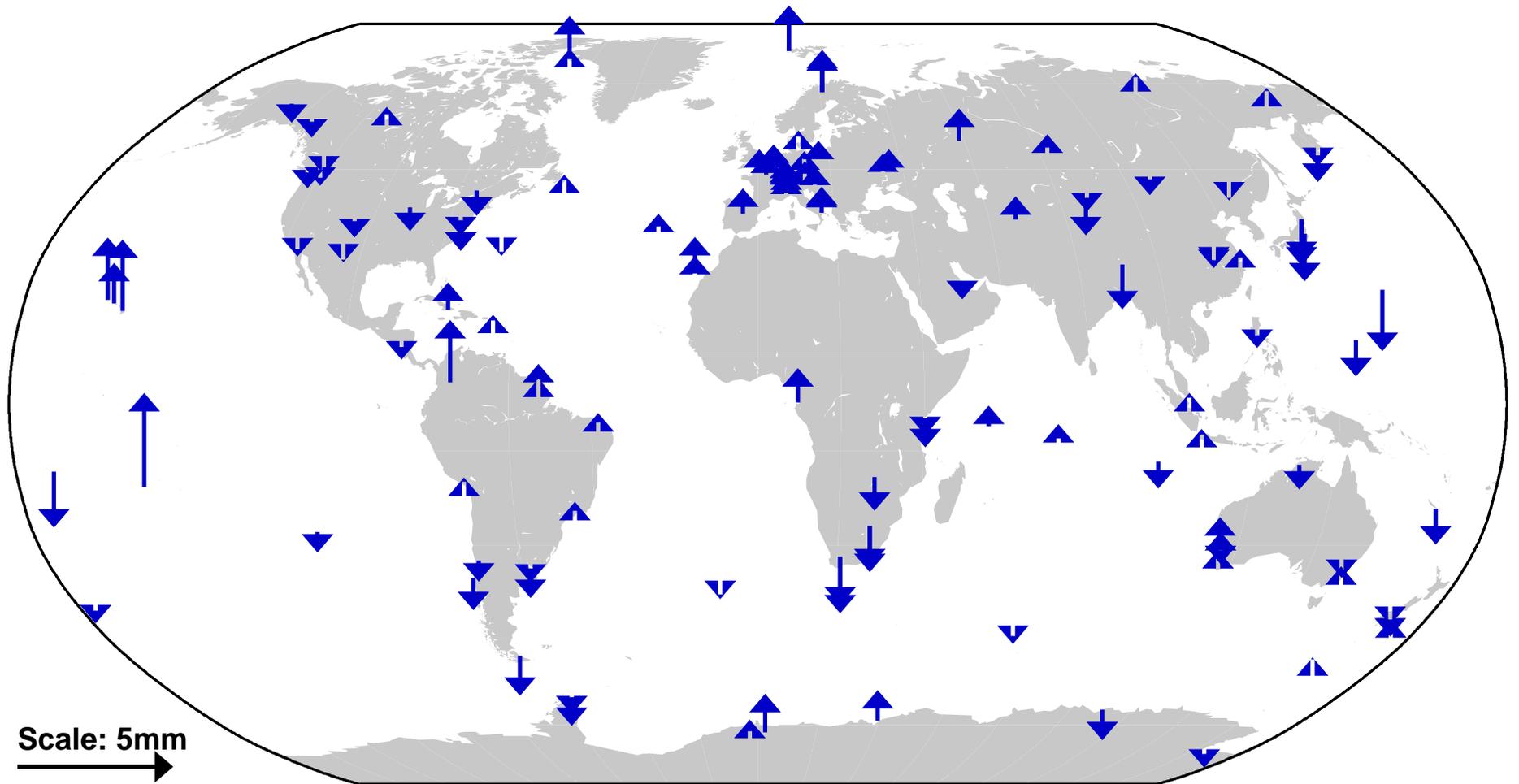
Bernese GPS Software (with NNR and NNT); week 1472; Up component

Coordinate differences between “free orbit” and “default” solutions



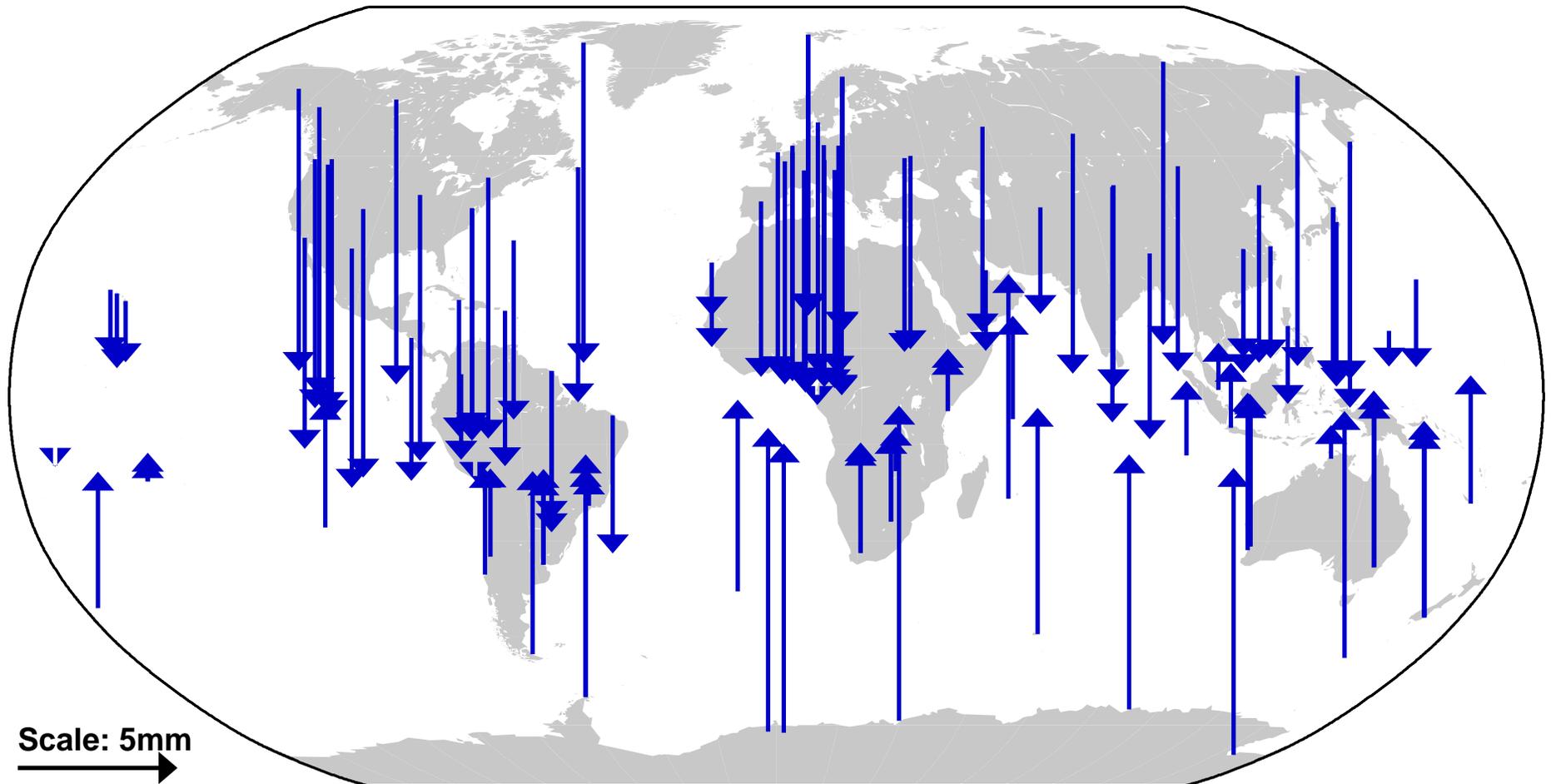
Bernese GPS Software (with NNR and NNT); week 1473; Up component

Coordinate differences between “free orbit” and “default” solutions



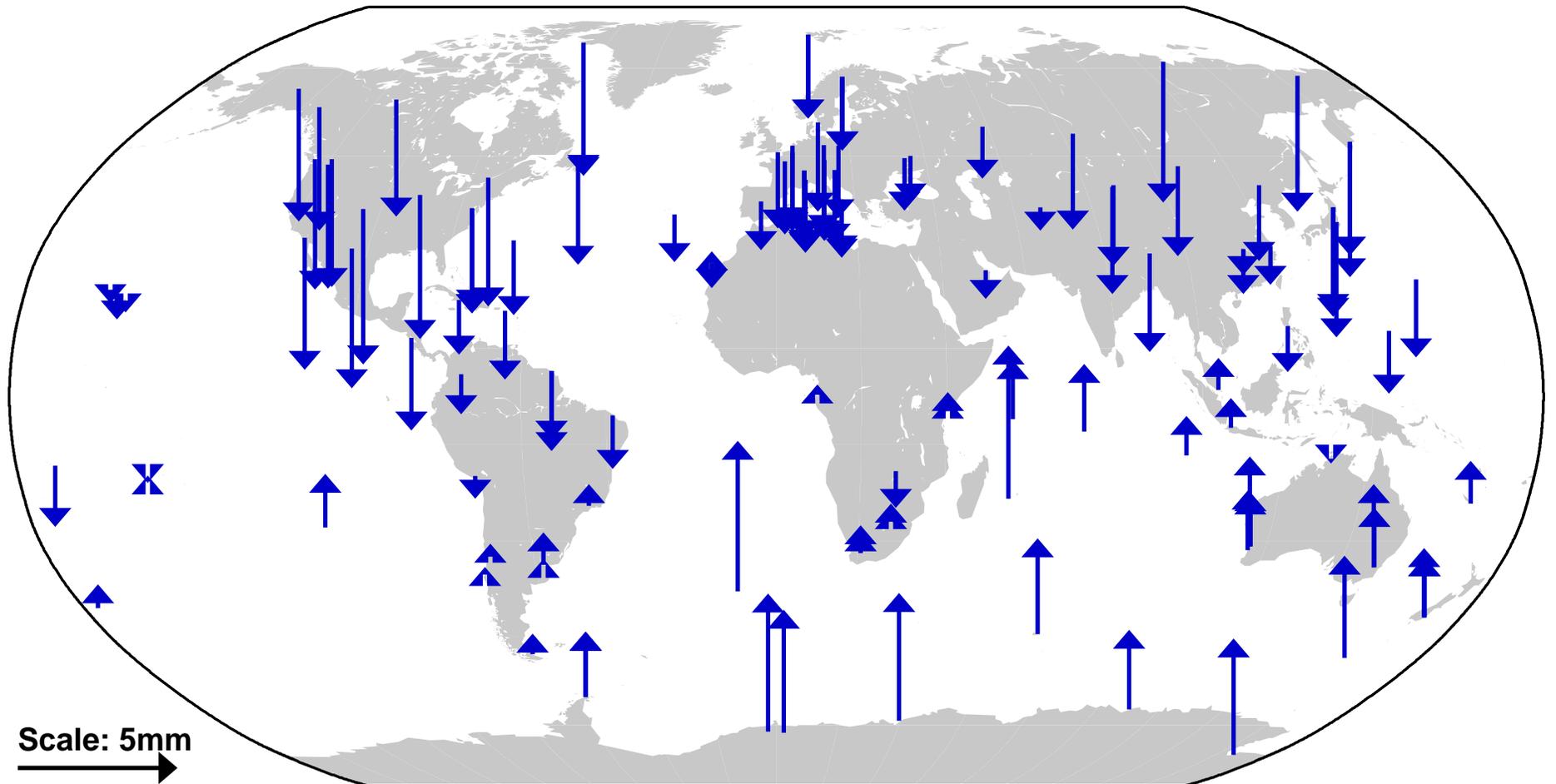
Bernese GPS Software (with NNR and NNT); week 1474; Up component

Coordinate differences between “free orbit” and “default” solutions



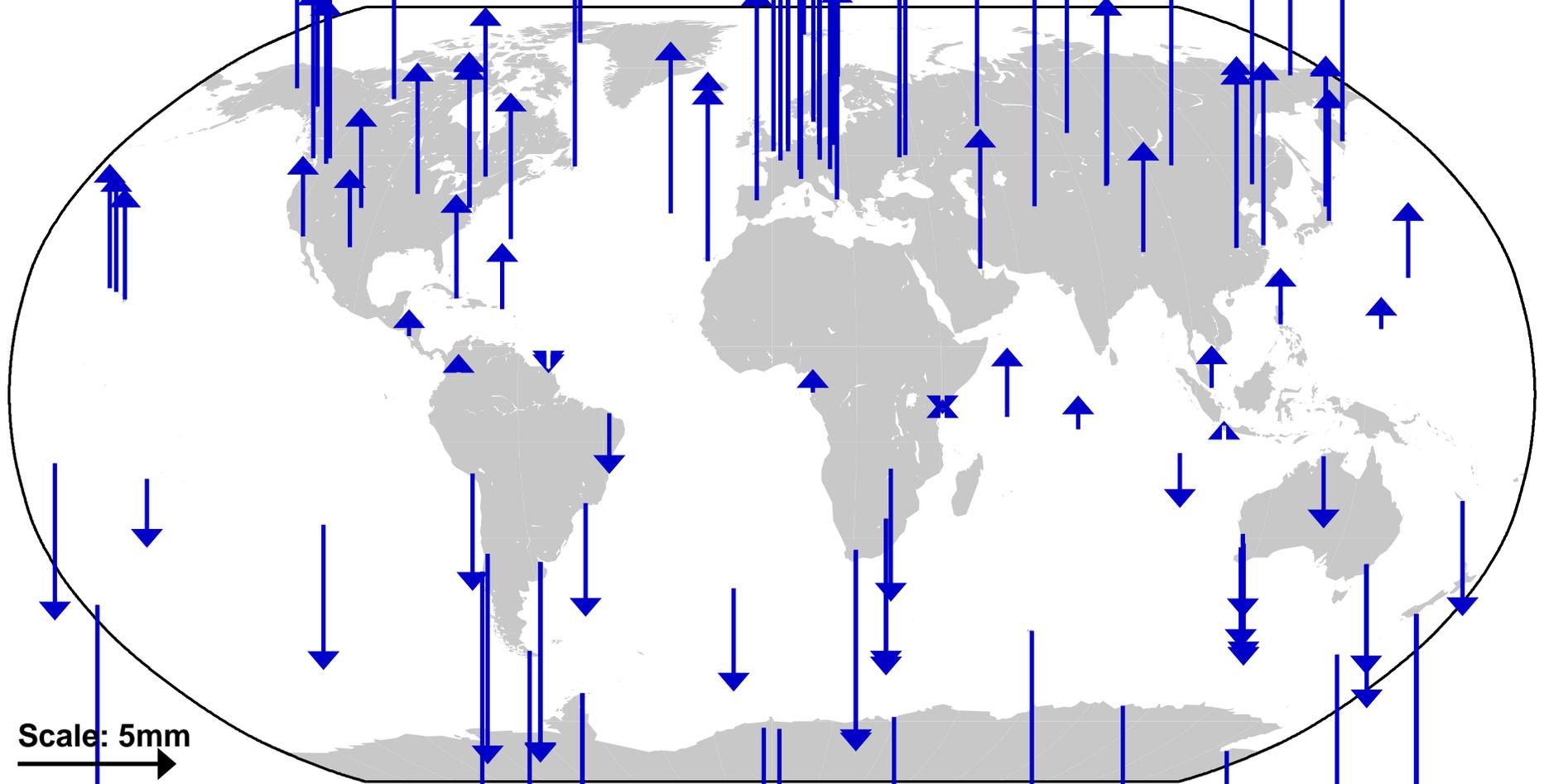
Bernese GPS Software (with NNR only); week 1471; Up component

Coordinate differences between “free orbit” and “default” solutions



Bernese GPS Software (with NNR only); week 1472; Up component

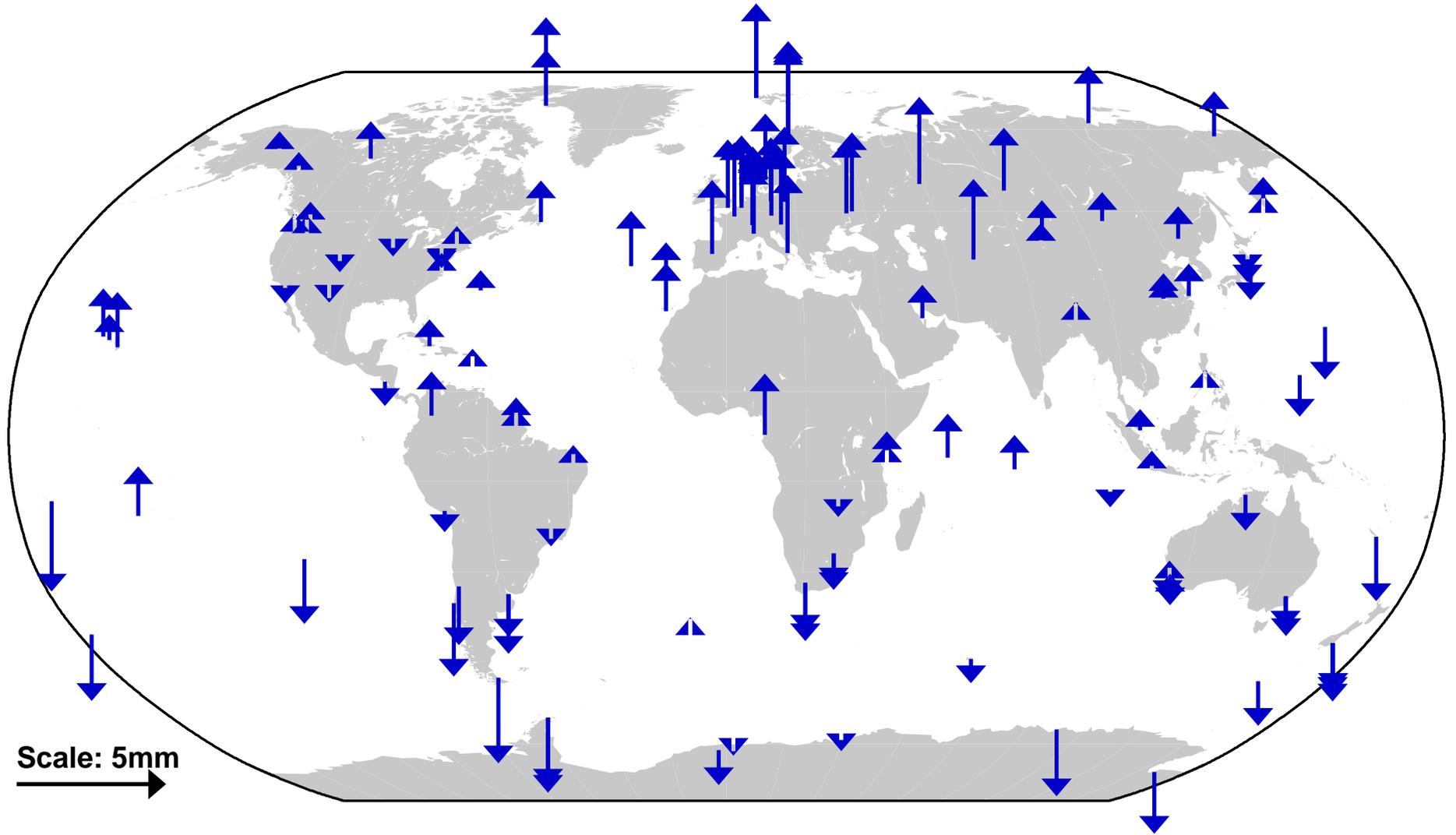
Coordinate differences between “free orbit” and “default” solutions



Scale: 5mm

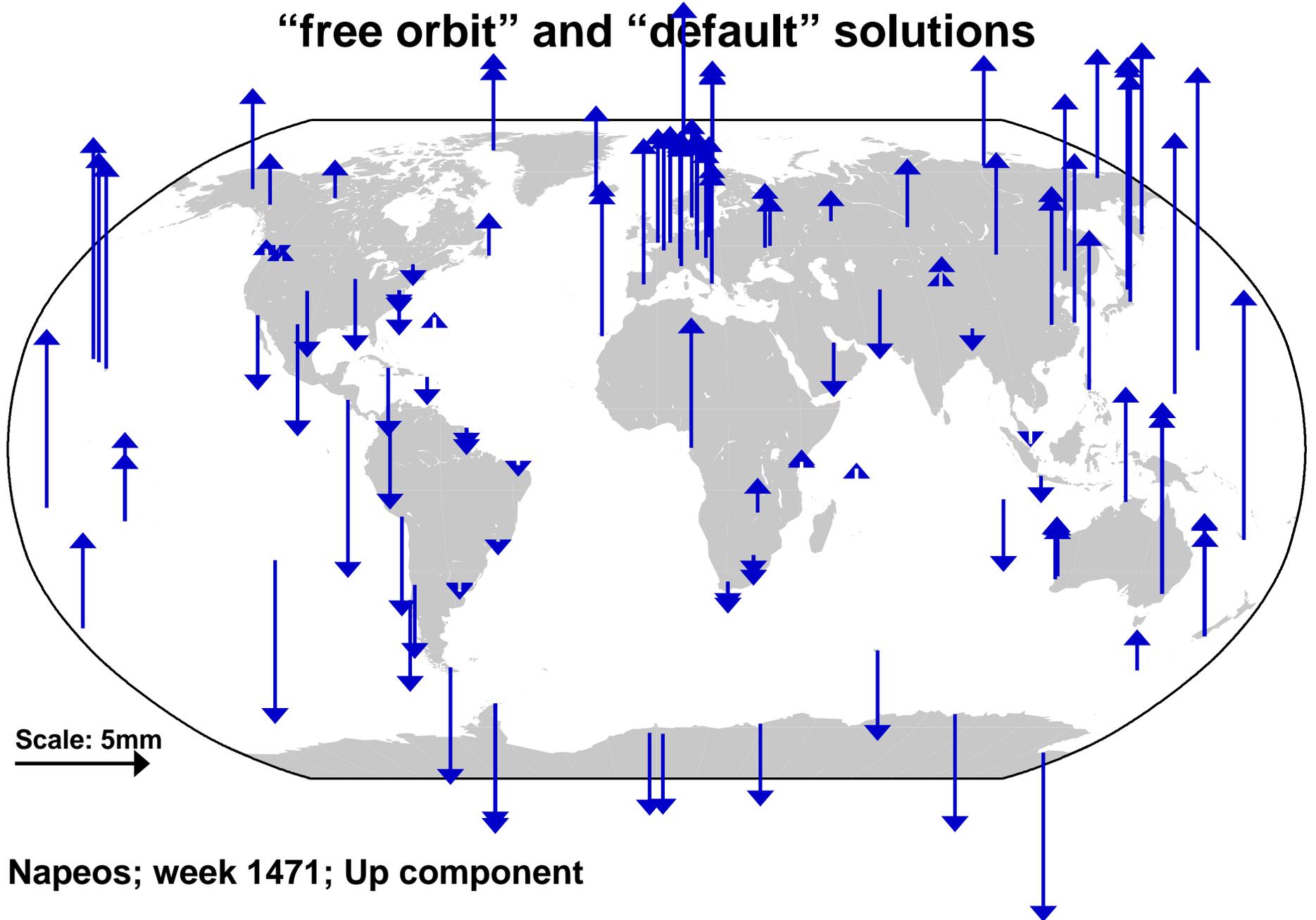
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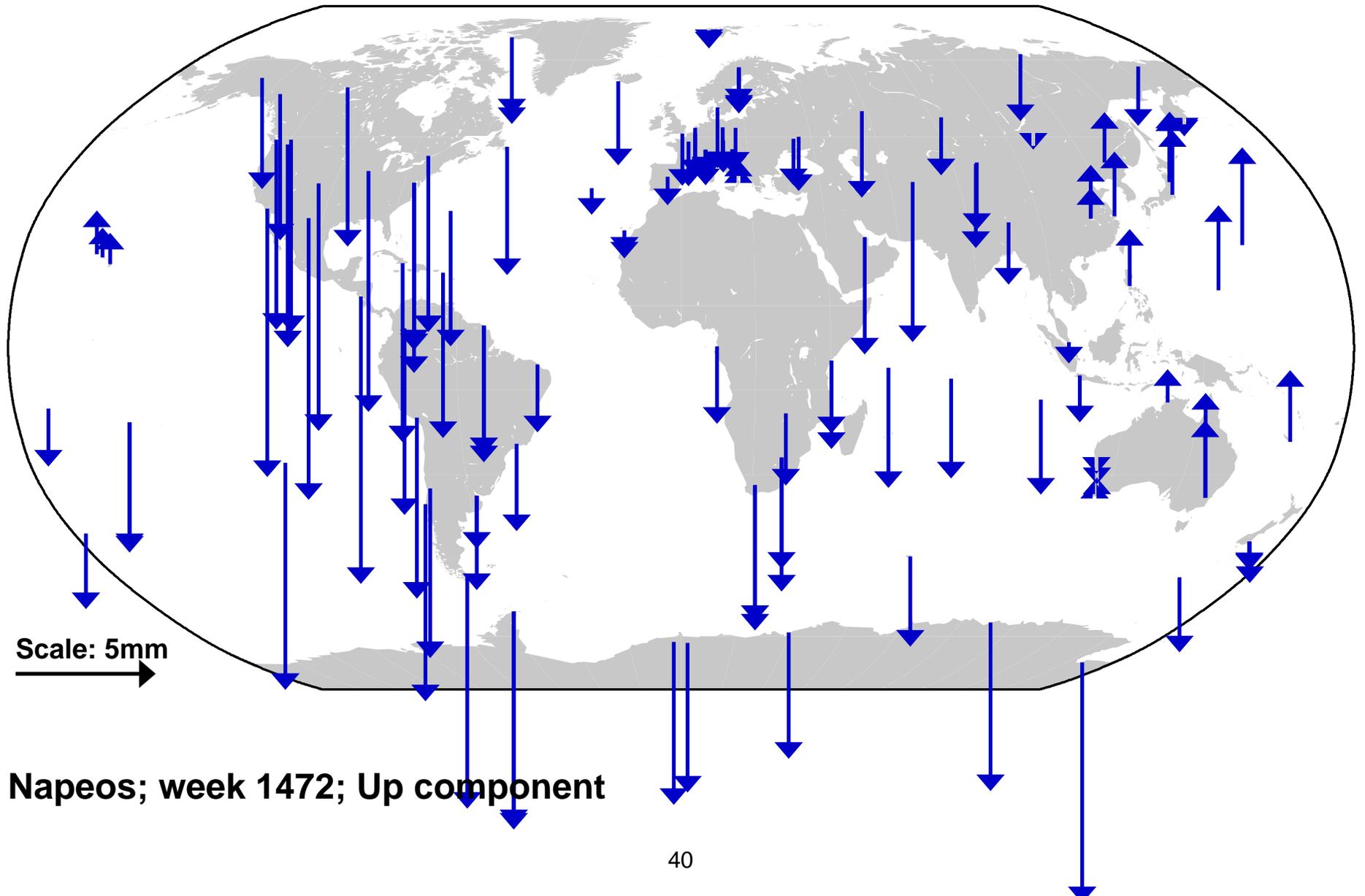
Bernese GPS Software (with NNR only); week 1474; Up component

Coordinate differences between “free orbit” and “default” solutions

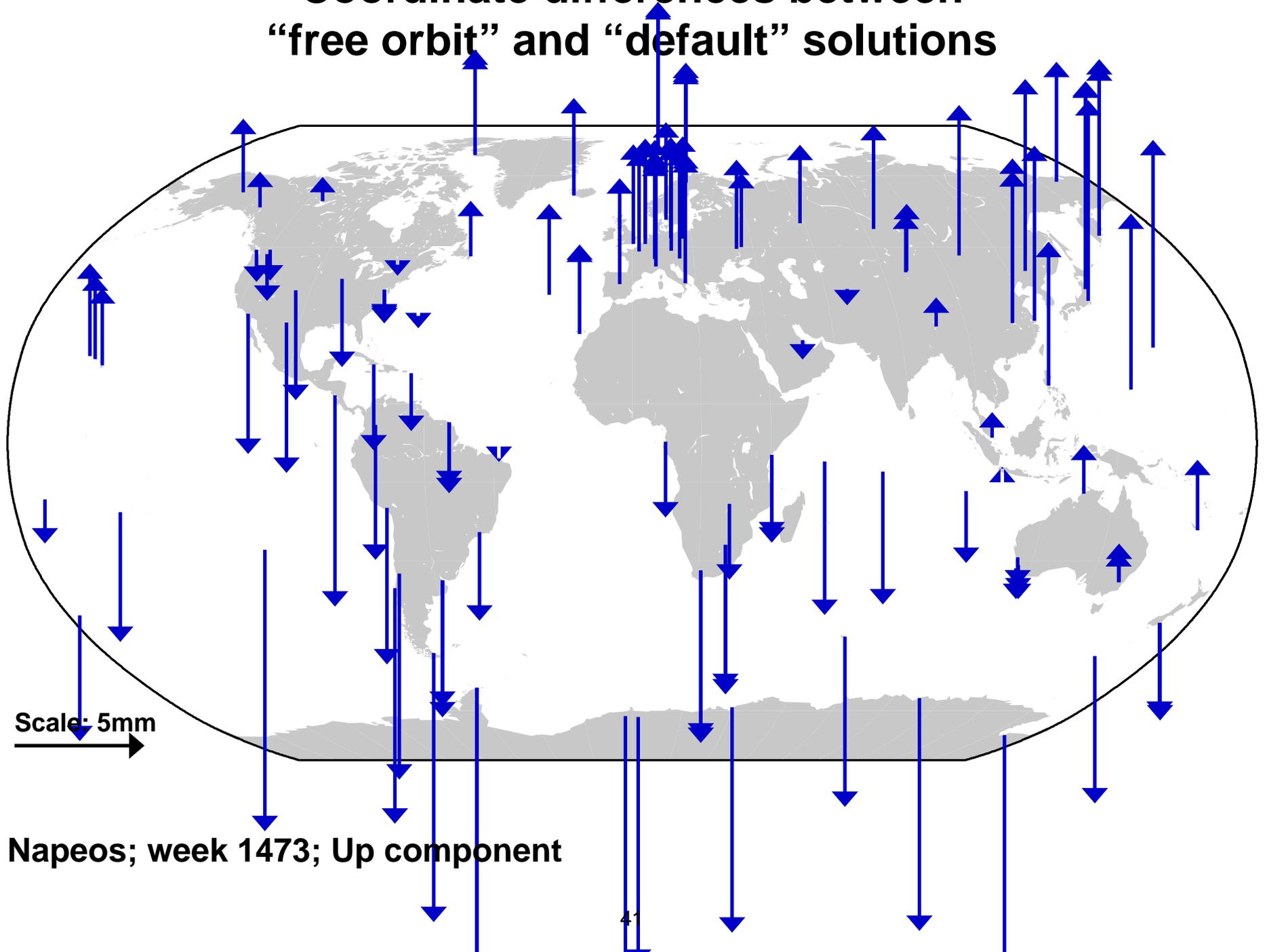


Napeos; week 1471; Up component

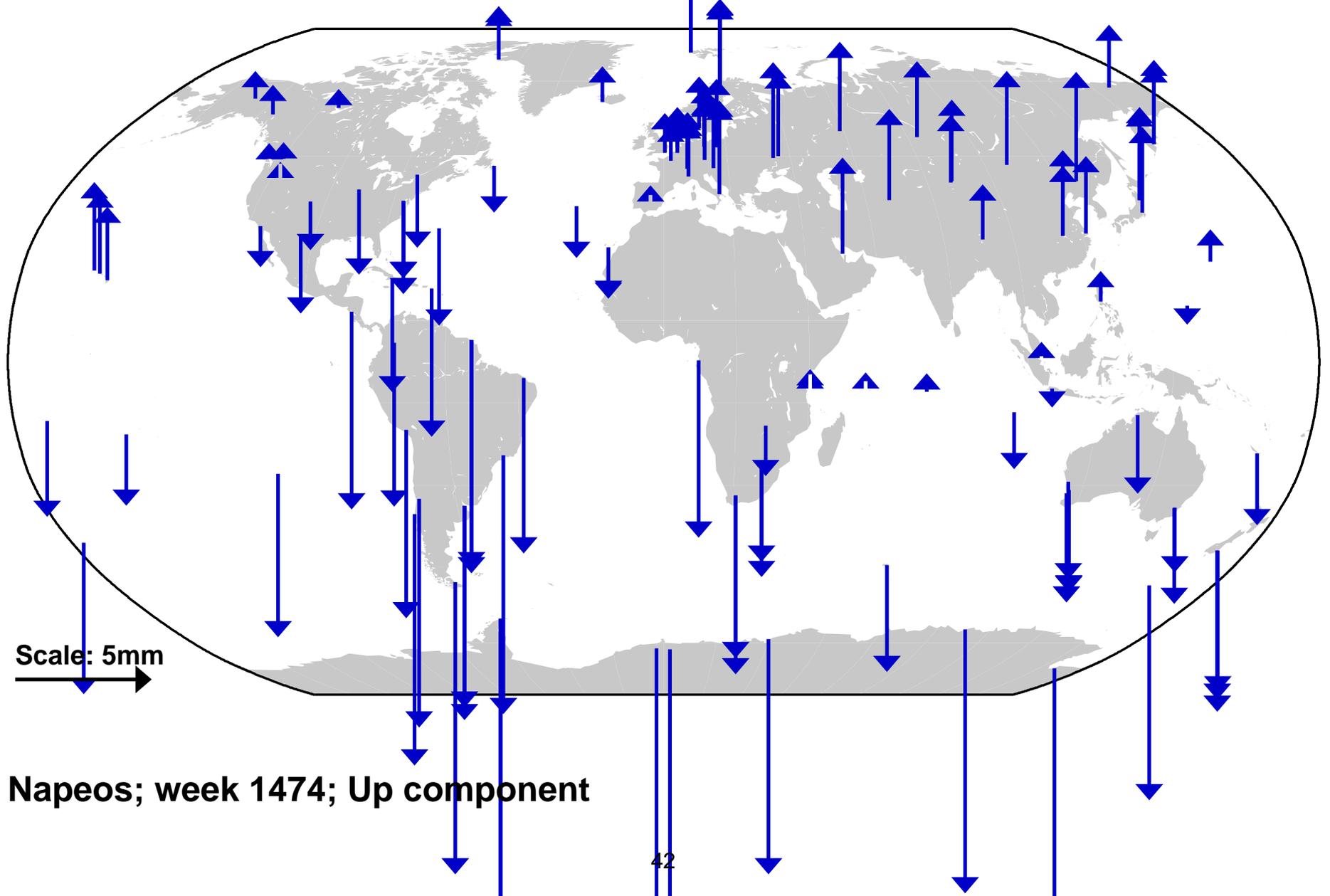
Coordinate differences between “free orbit” and “default” solutions



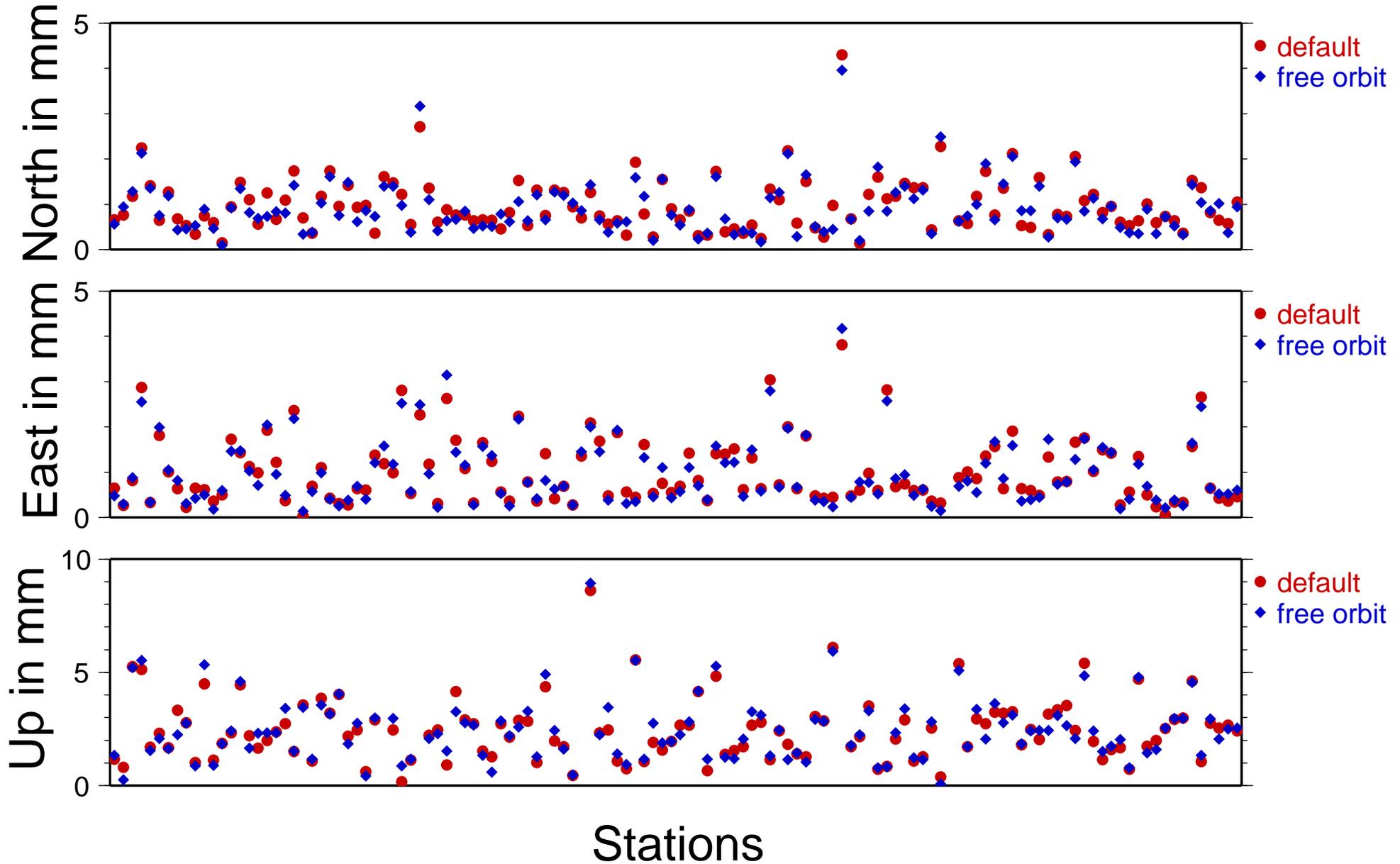
Coordinate differences between “free orbit” and “default” solutions



Coordinate differences between “free orbit” and “default” solutions

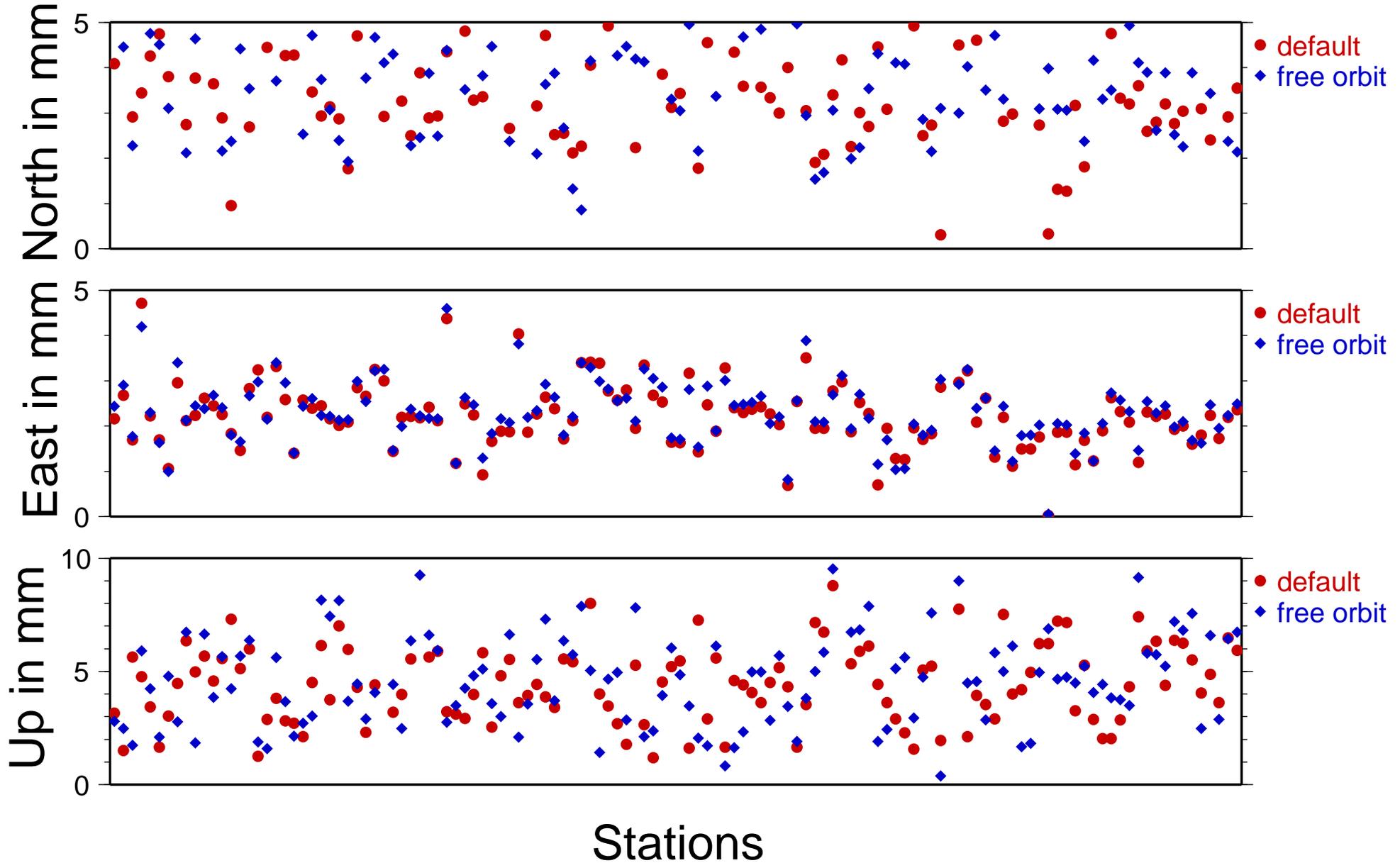


RMS of station coordinates from the 4 weeks

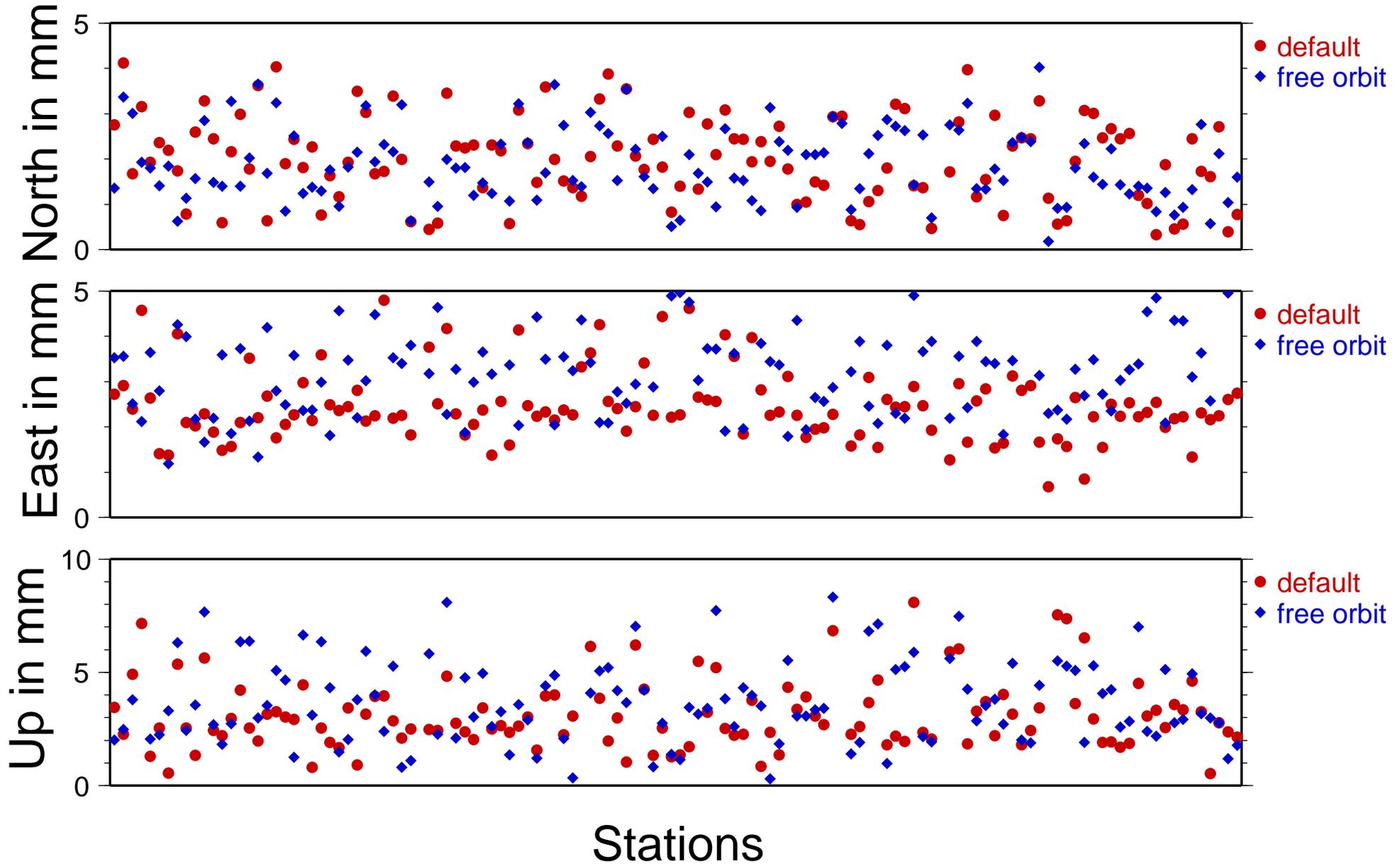


Bernese GPS Software (with NNR and NNT)

RMS of station coordinates from the 4 weeks



RMS of station coordinates from the 4 weeks



Napeos

Comparison of Bernese GPS Software solutions to IGS05 frame

Week 1471	TX(mm)	TY(mm)	TZ(mm)	scale(ppb)
default	-14.1	2.8	-5.7	0.43
free orbit	-13.9	3.6	-5.9	0.37
Week 1472	TX(mm)	TY(mm)	TZ(mm)	scale(ppb)
default	-10.5	3.1	-3.4	0.25
free orbit	-9.7	4.0	-3.2	0.19
Week 1473	TX(mm)	TY(mm)	TZ(mm)	scale(ppb)
default	-13.7	5.9	-11.7	0.25
free orbit	-13.0	6.8	-2.9	0.27
Week 1474	TX(mm)	TY(mm)	TZ(mm)	scale(ppb)
default	-12.7	7.2	-3.4	0.38
free orbit	-10.2	6.0	-2.7	0.38

Comparison of Napeos solutions to IGS05 frame

Week 1471	TX(mm)	TY(mm)	TZ(mm)	scale(ppb)
default	-6.8	-0.3	-9.2	0.64
free orbit	-7.0	0.2	4.1	0.54
Week 1472	TX(mm)	TY(mm)	TZ(mm)	scale(ppb)
default	-3.9	0.6	-5.2	0.41
free orbit	-3.6	1.2	6.3	0.37
Week 1473	TX(mm)	TY(mm)	TZ(mm)	scale(ppb)
default	-6.9	0.6	-9.5	0.31
free orbit	-7.7	1.8	6.0	0.27
Week 1474	TX(mm)	TY(mm)	TZ(mm)	scale(ppb)
default	-6.6	5.5	-9.3	0.43
free orbit	-7.1	7.3	41.7	0.40

Conclusions

- The orbit modeling (in particular the parametrization and constraining of parameters) has an important impact on the obtained station coordinates.
- Orbit parameters (in particular radiation pressure coefficients) may transfer into variation of the geocenter of the obtained station coordinate solution.
 - The magnitude of the resulting “variation” of the geocenter may become more than 1 cm.
 - The “variation” of the geocenter affects mainly the north and up component. The east component is less affected.
- When using a general constraint for the station coordinates when generating the weekly SINEX solution this must be considered (i.e., the constraint must be weak enough). Otherwise this effect cannot be removed anymore after pre-eliminating the orbit parameters.

On the other hand, in case of too weak constraints the solution becomes quasi-singular because the geodetic datum definition is missing.